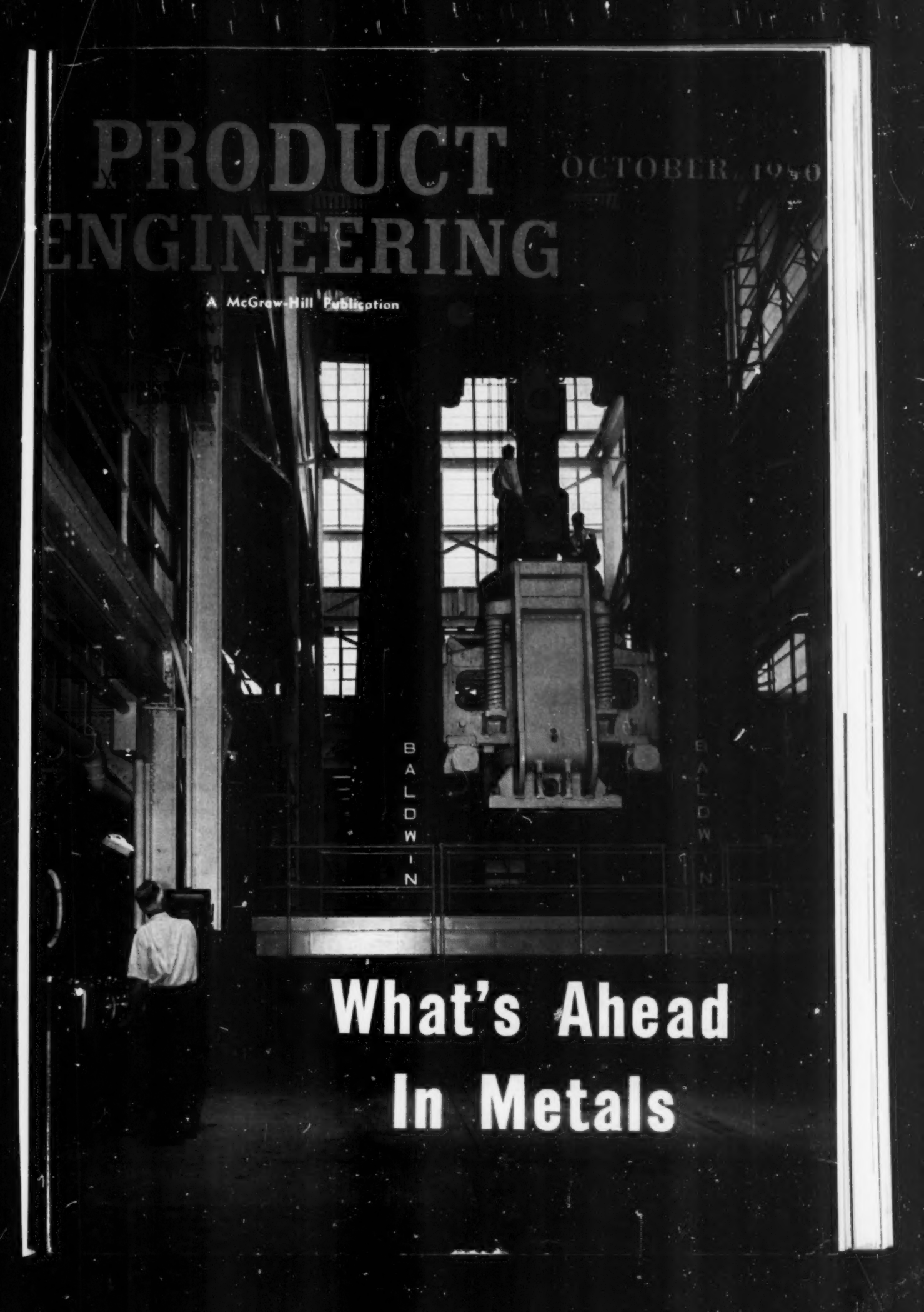
PRODUCT ENGINEERING

OCTOBER 1950

A McGraw-Hill Publication



What's Ahead In Metals

Why NICKEL SILVERS

constantly increase in popularity

NICKEL SILVERS are a group of lustrous copper-base alloys whose colors range from light pink to silvery white, depending on composition.

Their impressive beauty and moderate cost... and the fact that they can be readily cast and worked by ordinary methods... contribute to their great popularity.

Essentially copper-nickel-zinc alloys, their strength and corrosion-resistance in most cases exceed those of the corresponding brasses and bronzes, depending on nickel content.

MANY DIFFERENT TYPES

Nickel silver alloys may be: (1) hot-worked, (2) cold-worked and (3) cast.

The wrought forms are available as rods, wire, sheets, and tubes in many degrees of temper ranging from the *soft* types for drawing, spinning and forming, to the *very hard* required for flat or coiled springs.

In the harder tempers, nickel silvers develop relatively high tensile strength. For example, they reach approximately 145,000 p.s.i. in spring wire... obviously, an excellent material for small parts subject to considerable stress. Moreover, wrought nickel silvers are furnished in various ranges of grain size, from "fine" for polishing and etching, to "large" for forging and coining. Die cast and extruded shapes are also available.

ECONOMICAL TO FABRICATE

Nickel silvers promote economy and speed in fabricating all sorts of products. Applications include tableware, hollow ware, springs, keys, slide fasteners, weather stripping and parts for radios, television, telephones, typewriters, musical instruments, cameras, optical goods, fishing tackle and thousands of other articles.

CAST NICKEL SILVERS may be matched in color with the wrought forms. They are also complementary to chromium-nickel stainless steels and Monel®.

Nickel silver castings containing 20 per cent nickel are silvery white all the way through and exhibit the following properties:

Tensile Strength (cast)	40-60,000 p.s.i.
Yield Point (.5% ext.)	20-32,000 p.s.i.
Elongation in 2"	15-25%
Reduction of Area	15-30%
Coefficient of Expansion	0,0000091 per degree F.
Specific Gravity	8.70-8.90
Weight per cubic foot	540-550 lbs.
Brinell Hardness	75-100 (1000 kg. load)
Shrinkage (inches per foot)	3/16
Machinability	Readily machined by all methods

The cast forms are widely used by architects, decorators and builders, and extensively in hardware, packaging machinery, bottling machinery, dairy equipment and plumbing goods. Centrifugally cast cylinders and leaded bearings are also available.

COUNSEL AND DATA

Nickel silvers, wrought or cast, offer opportunities to increase product acceptance... and at the same time... to improve quality and cut costs.

The many standard grades of nickel silvers permit selecting one with the best set of properties for any reasonable fabrication and service demands. We shall be glad to furnish you with counsel and data on these versatile alloys.

EMBLEM OF INCO SERVICE

Over the years, International Nickel has accumulated a fund of useful information on the properties, treatment, fabrication and performance of engineering alloy steels, stainless steels, cast irons, brasses, bronzes, nickel silver, cupro-nickel and other alloys containing nickel. This information is yours for the asking. Write for "List A" of available publications.

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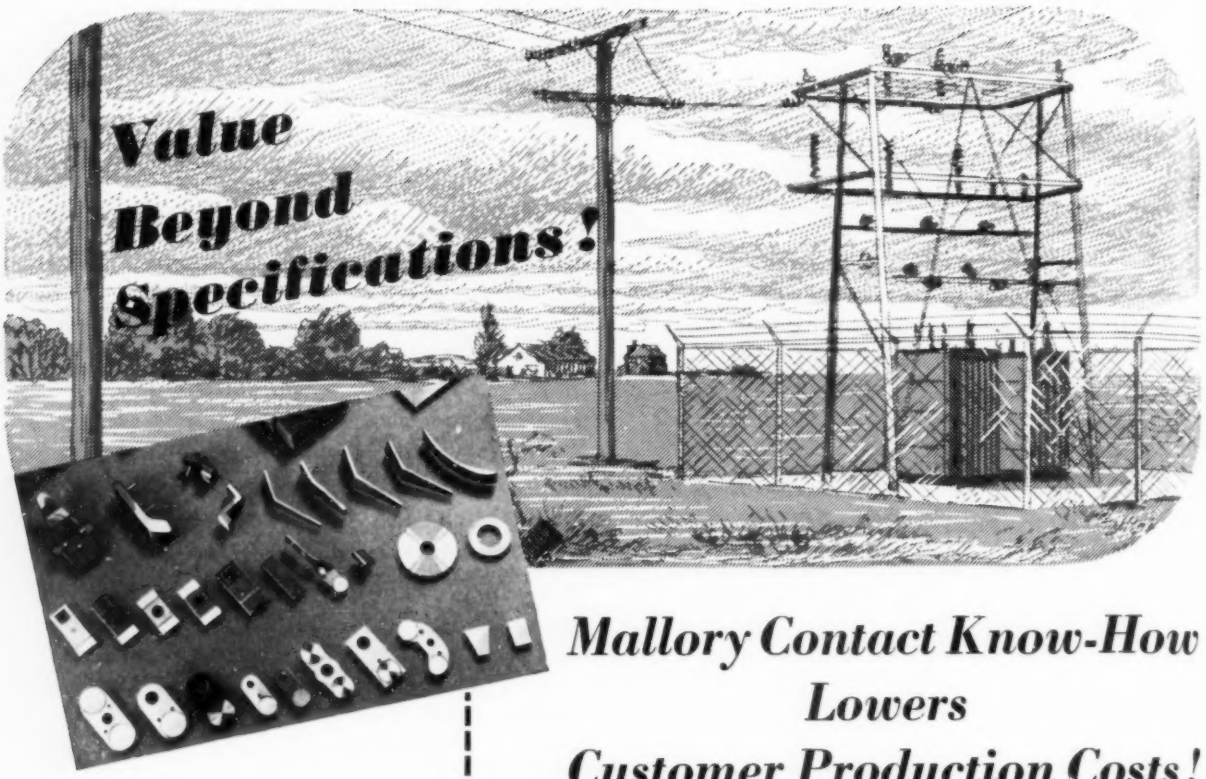

Mallory Contact Know-How Lowers Customer Production Costs!

Elkonite* Contacts

Elkonite is the trade name for a series of contact materials developed by Mallory and manufactured from metal powders. They are best known for their hardness, resistance to mechanical wear and impact, resistance to erosion by arcing, and resistance to sticking.

Elkonite contacts are made by the only method which permits the combining of the desirable features of basic metals which cannot be alloyed. By this means, the high melting points of tungsten, molybdenum, or their carbides, can be combined with the current-carrying ability of silver and copper.

Mallory digs deep for details when a customer presents a new contact application . . . and frequently the search leads to savings far beyond the specific contact problem.

Such was the case with a manufacturer of electric power transmission equipment who was designing a new product. As a by-product of Mallory's study of the contact application, the customer's engineers were able to recommend certain modifications in the basic construction of the equipment. As a result of these findings, the customer completely redesigned his product . . . and production costs were reduced by approximately $100 per unit.

That's value beyond specifications!

Mallory contact know-how is at your disposal. What Mallory has done for others can be done for you!

In Canada, made and sold by Johnson Matthey & Mallory, Ltd., 110 Industry St., Toronto 15, Ontario

Electrical Contacts and Contact Assemblies

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Capacitors	Contacts
Controls	Resistors
Rectifiers	Vibrators
Special Switches	Power Supplies

Resistance Welding Materials

Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

Metallic Materials

SUBSTITUTION of magnesium for aluminum alloys in a jet fighter wing resulted in several design improvements -- 31 percent fewer parts, 38 percent less fastenings. Skin thickness is 0.375 in. instead of 0.051 in., making it possible for the skin to carry two-thirds of the bending loads or twice as much as sustained by the aluminum assembly.

ACCELERATED OXIDATION of high temperature steels is one of the bugaboos that jet engine designers must overcome. Low oxides of Va, Bi, Mo, W and Pb contaminate the original oxide phase, causing disintegration of parts in a matter of hours. By minimizing contamination and adjusting alloy composition, researchers have been able to lick this difficult problem.

SO MUCH COLUMBIUM has been allocated for use in turbine blade materials that stainless steel producers didn't have enough for making types such as AISI 347. Equal parts of titanium and columbium proved a satisfactory substitute, while titanium alone filled the bill in all instances except specific corrosive applications.

ALLOWABLE DESIGN STRESSES in non-ferrous metals used in equipment subject to the ASME boiler code are now limited to the lowest of the following values: a quarter of the tensile strength, two-thirds of the yield strength, 80 percent of the stress-rupture and 100 percent of the creep rate based on not more than 0.1 unit creep rate.

EXTENSIVE TESTS indicate that molybdenum can be formed, machined, joined and finished by conventional methods; only stipulation is that fabrication temperatures must not fall below 70 F. The high-strength and modulus-of-elasticity properties of molybdenum can thus by capitalized in high temperature (above 1,900 F) applications.

AN ALUMINUM RACE cuts the bearing costs of a television antenna rotator mechanism. Bearing consists of a steel band around hardened, ground steel balls that ride in the die cast aluminum race. Less weight and improved corrosion resistance are additional benefits of this design.

MODIFIED FERRITE is reported to have a permeability about ten times that of the best powdered iron alloys. Material is already in use as a built-in magnetic antenna system that replaces a wire loop. Low energy loss characteristic makes the alloy ideal for transformers and deflection yokes.

Nonmetallic Materials

BETTER SYNTHETIC RUBBER can be made if waste from spruce paper mills is used in compounding. New chemical is PADMS, short for para alpha dimethyl styrene. Experimental tires made of the modified composition perform just as well as do standard GR-S assemblies.

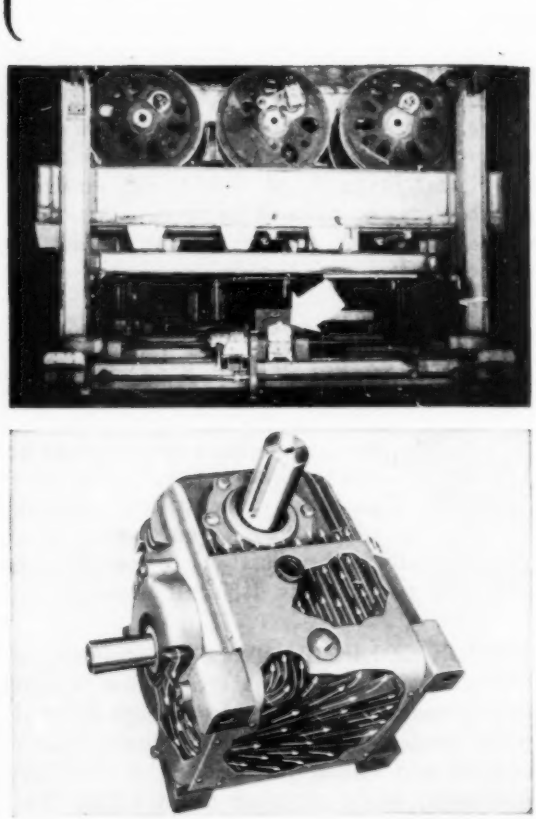
FLAME-RETARDANT INSULATION does not burn after a flame has been removed or drip when molten. Electrical characteristics are comparable to those of polyethylene. Plastic is non-tracking, has excellent low-temperature and good mechanical properties; can be extruded over wire or injection molded.

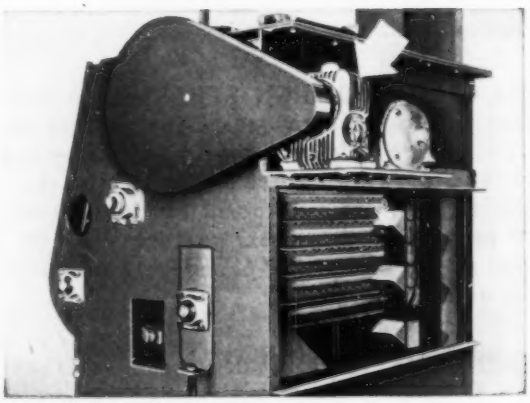
WATER DISPERSIBLE buffing and coloring composition for all non-ferrous metals except nickel is particularly effective for deeply filigreed surfaces. Post-buffing cleaning is no problem, just pass buffed part through an aqueous solution of a mild alkaline cleaner to get the coloring matter out of the recesses.

SMUDGE-PROOF LABELING TAPE resists water, oil and acids at temperatures up to 150 F. Blue- or black-edged strips 5/8 or 3/4 in.

Continued on Page 7

Rx – to reduce { GEAR SIZE GEAR WEIGHT GEAR COSTS





Cone-Drive Gears and speed reducers offer a remarkably simple and effective reducing formula for cutting the size, weight and cost of power transmitting drives.

The ingredient that does the trick is "double-enveloping gearing"—the exclusive Cone-Drive construction that gives you more contact per tooth, more teeth in contact and greater load carrying capacity for any given size.

The exact savings—in inches, lbs. and dollars—depend of course on the individual installation. Here are three typical examples:

Right above—Whiting model BW four-screw two-motor Drop Table; hoisting capacity 125 tons. Normally 10-inch center distance speed reducers would be required to handle this load. With Cone-Drive, Whiting gets all the load capacity it needs plus ample reserve using only 6 inch center distance units.

Right center—This fan-cooled Cone-Drive handles 5½ hp at 870 rpm, Class I service (continuous load). Comparing it with non-Cone-Drive reducers for the same load reveals a saving of $95 to $257, depending on whether you pick an 8" fan-cooled or a 10" non-fan-cooled reducer to do the job.

Right below—The manufacturers of automatic tumbling and cleaning equipment for castings and forgings are quite frank as to why they use Cone-Drive Gears to operate drives to their mills and loaders. ". . . they conserve space, give us freedom from service troubles and SAVE US MONEY."

CONE-DRIVE GEARS

CONE-DRIVE GEARS

Division, Michigan Tool Company

DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS

7171 E. McNichols Road • Detroit 12, U.S.A.

wide are built up of two layers of acetate sheet with a carbon identifying preparation sealed in between.

UNIFORM WRINKLE PATTERNS can be produced with a coating based on terpene phenolic resin. Ability of this resin to form wrinkles of uniform texture even though the film thickness varies means a reduction in costs because little or no stripping and rewashing is necessary.

ELASTIC PORCELAIN LINING for iron and steel tanks expands and contracts at same rate as base metal. Ceramic withstands temperatures ranging from freezing to 230 F, yet does not crack or check.

SUPER REFRACTORY is claimed to be more resistant to thermal shock than any commercial ceramic. Containing no readily reducible oxides, material is highly corrosion resistant, retains room-temperature bending strength at 1,000 C and is recommended for continuous service at 1,200 C; can be made in virtually any shape and held to a production tolerance of +0.5 percent.

Processes

SOLVENT WASH, the cause of streaky enamel on sprayed or dipped sheet metal products, can be avoided by striking a balance between adhesion characteristics of the paint solvents and the metal surface. The surface tension in the liquid must be reduced to the point at which maximum wetting action is consistently obtained.

STUDS up to half an inch in diameter can be welded to dissimilar metals by using energy stored in condensers. Studs have a small metal tip that contacts the work and melts when an arc is struck as the condenser discharges. Formation of the arc is independent of the resistance in the metals.

A BASIC CHANGE in the art of drawing wire may soon become evident. Called prestressing, back-pull or reactive drawing, process involves applying a back tension while the wire is stressed to half its yield strength. Advantages: less friction and heat generated between die and wire, better finish on the wire and less power for drawing.

CHROMIUM SHEET that can be readily cut and bent when heated above 930 F has been produced in two different ways: by aqueous electrolysis of the hexavalent salt and by reduction of the chloride with magnesium. The ductile material is highly corrosion resistant and easily machined.

SHORT-CUT METHOD for producing carbon dioxide makes use of a "fluidized powder". A stream of pure carbon dioxide gas is blown through a mixture of powdered coke and iron ore. Once stripped of its oxygen by the coke, the ore is regenerated with oxygen from the air and used again.

ULTRASONIC ENERGY and a special soldering iron containing a magneto strictive transducer simplify soldering of aluminum assemblies. High frequency vibrations shake the metal surface clean so that no flux is needed before tin-zinc soft solders are applied to the joint.

ELECTRODE WIRE only 5/64 in. in diameter fed into a joint from a special gun permits 600-amp welding at speeds normally associated with units requiring 10,000 amp. High current density is the result of the wire's small cross-sectional area. Feeds for both wire and granular flux are automatically regulated by metering mechanisms in the gun assembly. Trade name is Hidensity welding.

Components

TINY PHOTOCELLS currently being perfected depend on germanium for their sensitivity to slight changes in light intensity. Potential uses are for decoding punched tape, computing and sorting, as well as for the direct operation of relays that open and close doors.

A STANDARDIZED LINE of a-c timing motors is now being marketed. In addition to having high starting and running torque, the motors operate at full synchronous speed despite variations as great as 25 percent in the line voltage. Wide range of speeds and current ratings eases problem of fitting the motor to the job.

A STANDARD LINE of large bracket-bearing, squirrel-cage induction motors has been re-

Continued on Page 9

Another new development using

B. F. Goodrich Chemical Company ***raw materials***

what the well-dressed man wears

—WHERE DANGEROUS CHEMICALS ABOUND

"Gra-Lite" clothing made by Standard Safety Equipment Company, Chicago, Ill.
B. F. Goodrich Chemical Company does not make this fabric. We supply raw materials for the coating only.

ANY man who works around dangerous chemicals will tell you how necessary safety clothing is. Especially important is the length of time it *resists* chemicals. For if red fuming nitric acid should touch the clothing, a matter of extra minutes of resistance makes the difference between safety and serious, or fatal injury.

The Geon resin coated clothing pictured gives workmen that all-important time-margin of safety. The Geon coating not only gives high chemical resistance, but also an increased period of resistance.

That's just the start of the Geon coating's advantages. It has excellent abrasion resistance. It's light in weight. A suit of overalls like the one pictured weighs only 27 ounces. Geon's color-adaptability is another big help. It can be compounded in light colors—the pearl gray used here providing improved reflection of sunlight, increasing comfort to the wearer.

There's added safety in Geon's flame-resistance. And the coating's flexibility at low temperature is important for outdoor winter work.

Geon materials have many advantages that help improve products—improve their sales, too. Products of Geon can be made resistant to heat and cold, weather and wear—to water, grease, oil, oxidation and many chemicals. Colors can be brilliant or delicate. We'll gladly give you helpful advice on the many uses and applications for Geon. For technical bulletins, please write Dept. GO-5, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco.

GEON RESINS • GOOD-RITE PLASTICIZERS . . . the ideal team to make products easier, better and more saleable
GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers

designed for greater protection and accessibility. Upper half of bracket can be removed to permit servicing of capsule-type sleeve bearings; and removable louvers in the stator yoke vent openings make it easy to clean the passages behind the stator core.

ASSEMBLY of sheet-metal products is a lot simpler if an ingenious cage nut is used.

Two loops punched out at 45 deg angles in the metal sheet form the cage. A special nut with two flat wings is placed between the loops, which are then pinched up over the wings.

A SLIGHT TWIST with a wrench swages a new type coupling on air hose. Coupler-clamp has an inner shank sealed into an outer housing that has a hex on each end. After hose is slipped over the shank, the thin-walled diagonally-slotted center section of the housing is twisted, thus crimping it on the hose.

LATEST MINIATURE BATTERY weighs only 400 grams, takes up just 16 cu. in. of space. Its main elements are magnesium and cuprous chloride that are activated by tap water. Capacity of 12 watt-hour is not impaired, even though temperatures may be 65 F below zero.

Testing

CORRELATION between surface brightness and brazability is the basis of a simple technique for testing the brazing properties of cupro-nickel specimens. Unbrazable material can thus be spotted before unsuccessful attempts in the shop tell the sad story.

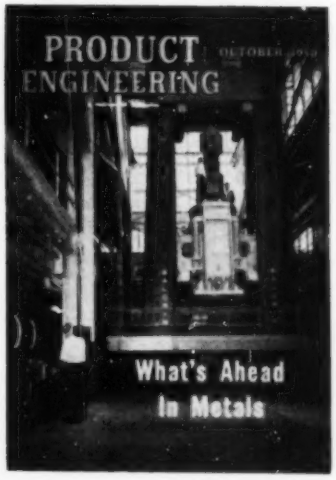
DIAPHRAGMS made of silicone rubber-coated Orlon are particularly responsive to small pressure differentials. Mechanical, thermal and electrical properties are consistently good throughout temperature range from -75 to +300 F. Diaphragms 0.010 or 0.017 in. thick can be either flat or convoluted to fit a particular application.

ONLY TWO POUNDS of fuel are consumed every minute in a tiny rocket engine used for testing contact-type liquid propellants. Both cheaper and safer than full scale rocket experimentation (the V-2 used twelve tons of fuel per min), facility will play a big part in the government's weapons development program.

EXPLODING ATOMS of nitrogen iodide make it possible to produce a direct print in an ordinary camera. When light strikes special print paper coated with the black chemical, a chain reaction of tiny explosions takes place, turning the paper white according to the light's intensity. Lack of control over the chemical is preventing commercialization of the process.

A COUNT RATE METER is an added attraction in a high-speed electronic tachometer, making the instrument useful when an unknown frequency source is being traced. This type indication reflects instantaneous changes and eases manual adjustment to any desired setting.

ACCELERATED ABRASION TESTS can be run on an experimental machine that simulates actual service conditions. Rig is fully instrumented so that complete data are recorded during tests that take minutes instead of months.



THIS MONTH'S COVER

Symbolic of the incessant demand by engineers for specific and detailed information on strength of materials in large section sizes is the new 5,000,000 lb capacity universal testing machine at the recently dedicated testing laboratory of the Bureau of Reclamation at Denver, Colorado. Up to now, the effect of section size on the tensile and compressive strength of materials—sometimes called the "mass effect"—has frequently been difficult to predict.

The machine, which was designed and built by the Baldwin-Southwark Division of the Baldwin Locomotive Works, is about 50 ft high, weighs approximately 750,000 pounds, and is believed to be the largest of its type in existence. Photograph by W. M. Botts, Bureau of Reclamation, Denver, Colo.

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by BRIDGEPORT BRASS COMPANY "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

Hot water thermostat and component parts—Courtesy Camstat, Inc., Los Angeles, Calif.

Seven Copper Alloys Resist Corrosion in Bi-Metal Switch

Rusting and other forms of corrosion change the electrical characteristics of parts, decrease strength of springs and jam bearing points in small control instruments.

To combat such conditions, copper-base alloys were primarily selected for all functional parts in the illustrated water heater thermostat. This unit operates with a bi-metal actuator which curves forward as the result of one metal expanding more rapidly than another.

Since each copper alloy has different mechanical and physical characteristics, seven were used in this unit, and, in some cases, several tempers for each alloy.

Cartridge brass, 70% copper and 30% zinc, because of its ability to withstand heavy working better than high brass, is used for the cover (1), bracket (2), pointer (4), yoke (9), and staple (3). Half hard metal was necessary to permit drawing, forming and bending of the cover, pointer and yoke, and in the staple to permit the prongs to be bent at assembly. The bracket is spring hard (8 numbers) as it acts as a flat spring.

Phosphor bronze Grade A, 95% copper, 5% tin, 0.15 phosphor, produces flat springs in light gages (0.006 and up) due to its excellent spring properties and resistance to fatigue. This alloy is used for the contact springs (16), push button spring (17), spring link (18) and flat spring (20). All have spring temper.

Nickel Silver Grades A, B

Two grades of Nickel silver find use in this unit. In the pivot bracket (8) grade B, 55% copper, 18% nickel and the remainder zinc, gives the part fine spring characteristics, high strength (better than 90,000 psi in its extra hard temper), and the ductility in this hard state to permit heavy bending and forming.

Grade A, 65% copper, 18% nickel and remainder zinc, has greater ductility than B which permits dimpling, bending and forming on the actuating lever (10). The base metal is hard (4 numbers) and has a tensile strength of 85,000. The coldworking done on this lever increases its strength to around 90,000.

Several Parts Machined

Free machining brass rod, with the highest machinability of the copper alloys, can be accurately machined with good finishes at high speeds. For these reasons, it is used for the counterweight (shown on assembly 9), adjusting nut (5), terminal (6), stub (7), and calibrating screw (12). This alloy also has a conductivity 26% that of copper.

The hollow rivets (11) and (13) are produced in cold headers from 70-30 (cartridge brass) wire. When the hollow rivets are such that drilling is required rather than extrusion in the header, a light leaded wire is used (65% copper, 0.3% lead and remainder zinc) to facilitate the drilling.

The cold headed and roll threaded screws (14) and (15) are made from high brass, 65% copper, 35% zinc. Although not as ductile as the cartridge brass used in the hollow rivets, it is sufficiently ductile for medium-sized heads and roll threading.

Silver Rivets

The hollow rivets used for electrical contacts in the switch under the silver links are also of silver to eliminate danger of arcing.

Bridgeport's laboratory can be of help to product engineers in the selecting of the best alloy from a functional as well as fabricating standpoint. Write the nearest district office or contact Bridgeport directly.

BRASS · BRONZE · COPPER · DURONZE — STRIP · ROD · WIRE · TUBING

MILLS IN
BRIDGEPORT, CONNECTICUT
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In Canada:
Noranda Copper and Brass Limited.
Montreal

BRIDGEPORT BRASS COMPANY
BRIDGEPORT 2, CONNECTICUT
Established 1865
"Bridgeport" *District Offices and Warehouses in Principal Cities*

The Many-In-One Campaign

The helping hand is a builder of peace and understanding and to the builders come satisfaction and happiness. For emotional reasons, for humanitarian motives, or as a hard headed business proposition, or for all three of these reasons, support your Community Chest, the Red Feather Campaign, and yours will be the satisfaction that comes to those who help the other fellow.

Because these are our beliefs and convictions, we devote this editorial page to the presentation of a joint statement by two of the country's leading industrialists. We whole-heartedly endorse the closing sentence of the statement and express our wishes for a record breaking successful campaign.

We believe in the "many-in-one" campaign idea . . .

This year, Community Chests are uniting more than 15,000 health and welfare agencies in one big effort to raise approximately $190,000,000. This is to help finance such typical Red Feather services as Boy Scouts and Girl Scouts, Maternity Homes, and Visiting Nurses, Family Service, Travelers Aid, Neighborhood Houses and Legal Aid. Included too are Boys' Clubs and Camp Fire Girls, Urban League, Children's Aid, Hospitals and Clinics, and Services for the Aged. The Salvation Army, Y.M.C.A., Y.W.C.A., Summer Camps, Clubs for Girls, Aid to the Handicapped and Social Hygiene services are also members of the Red Feather family.

Being businessmen we see the advantage of uniting these many campaigns under one efficient, fund-raising organization. Industry knows that production costs drop as volume increases. Over 30 years' Chest experience proves that coordinated campaigns cost less, save time and energy and raise more money to provide more and better services. Big or small, federated campaigns guarantee effective use of the funds subscribed. They substitute order for the chaos that comes with many separate fund-raising efforts.

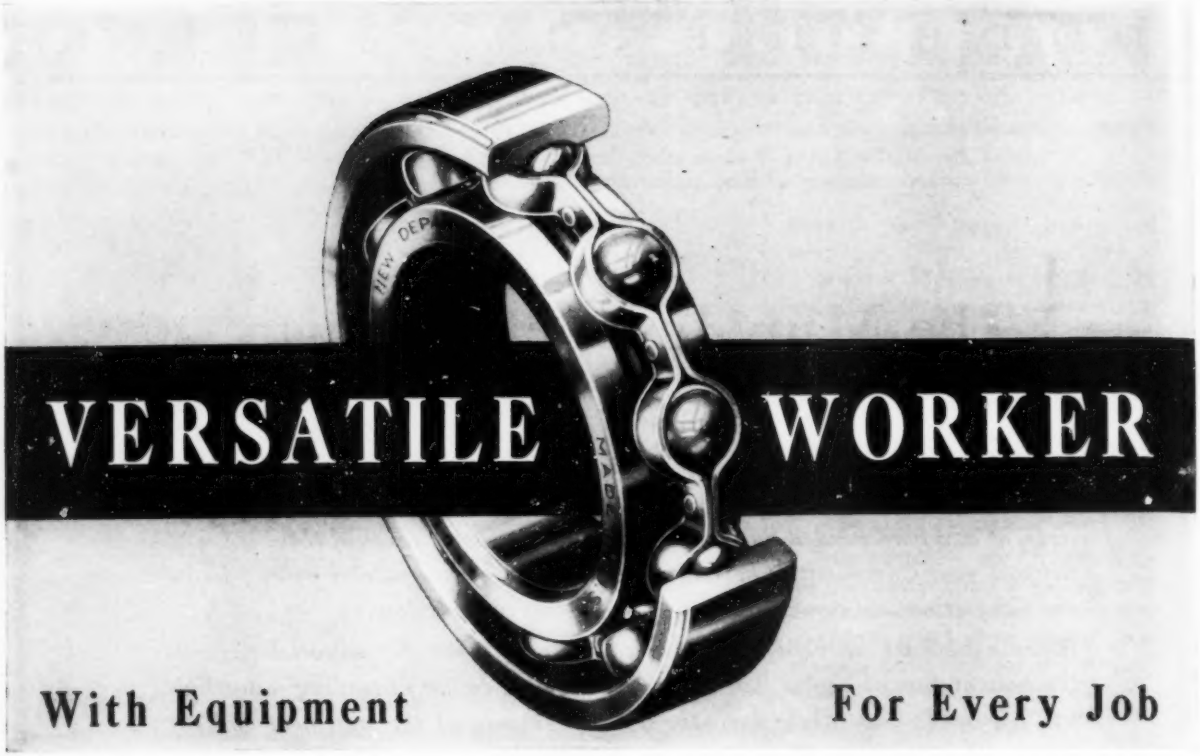
Proof that the "many-in-one-campaign" is effective lies in the fact that appeals are being federated in more and more local communities. Leaders of both management and labor, in civic clubs and governmental departments, from professional circles and educational groups are giving increasing endorsement to the idea of joint campaigning and budgeting.

The number of communities organizing Chests has steadily increased. In 1940 there were 561 reported Chests. By 1948 the number had grown to 1060. At the present time definite information is available about Chests in more than 1250 cities.

United campaigns are wisely planned, cooperative undertakings. We believe they make sense and should be supported generously . . .

CHARLES E. WILSON, *National Campaign Chairman Community Chests of America (President, General Electric Corporation)*

CHARLES E. WILSON, *Vice-Chairman Community Chests of America (President, General Motors Corporation)*



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With snap ring and either one or two shields as required.

With contact seals, lubricated for long life without attention.

A standard New Departure single row ball bearing may be had with about a dozen different combinations of seals, shields, snap rings, etc., to simplify mounting, lubrication or enclosure—in short it may be had with the equipment to do each specific job best.

But basically you always have one of the most useful and dependable workers ever devised—taking radial loads and thrust loads from either direction—locating parts accurately and permanently -all in one unit requiring no time-wasting adjustment or other attention.

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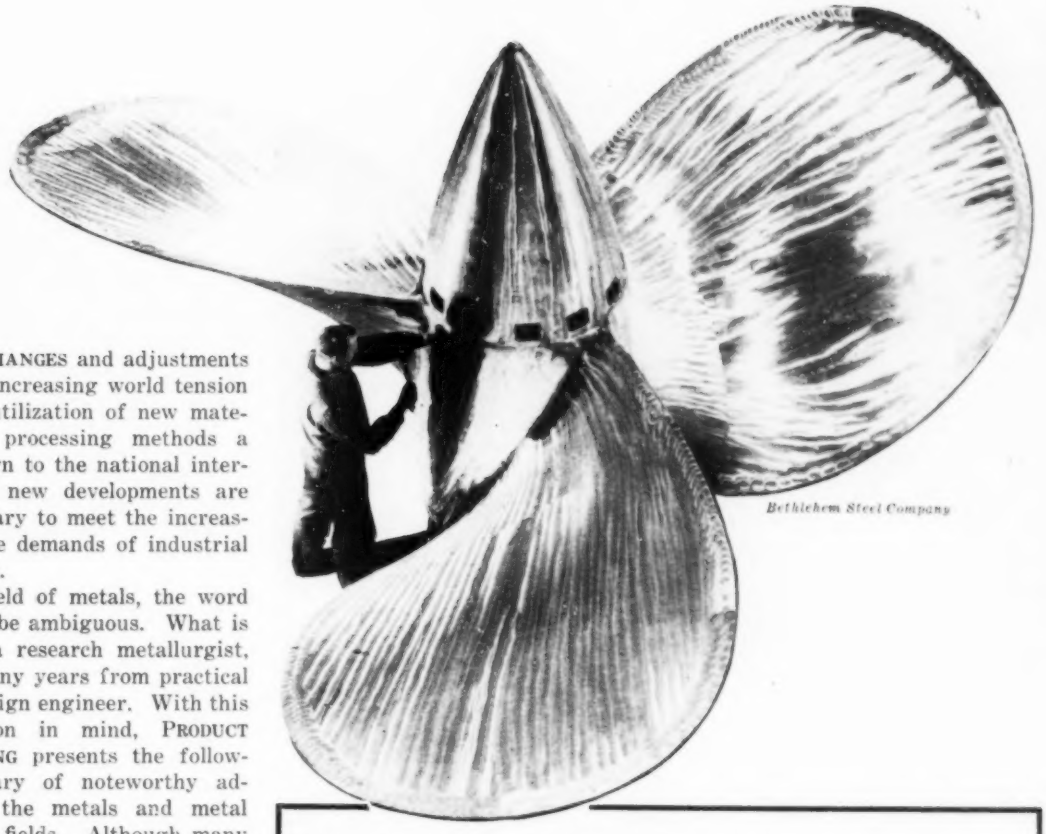
NEW DEPARTURE · DIVISION OF GENERAL MOTORS · BRISTOL, CONNECTICUT

.16

What's Ahead in Metals



Bethlehem Steel Company

SUDDEN CHANGES and adjustments caused by increasing world tension make the utilization of new materials and processing methods a vital concern to the national interest. Such new developments are also necessary to meet the increasingly severe demands of industrial competition.

In the field of metals, the word "new" can be ambiguous. What is "new" to a research metallurgist, is often many years from practical use to a design engineer. With this consideration in mind, PRODUCT ENGINEERING presents the following summary of noteworthy advances in the metals and metal fabrication fields. Although many of these developments are now "on the market", their significance has not yet been evaluated. Others are just out of the research stage. Metals and processes in both categories will reach their fullest development in the next decade.

The Next Decade Promises . . .

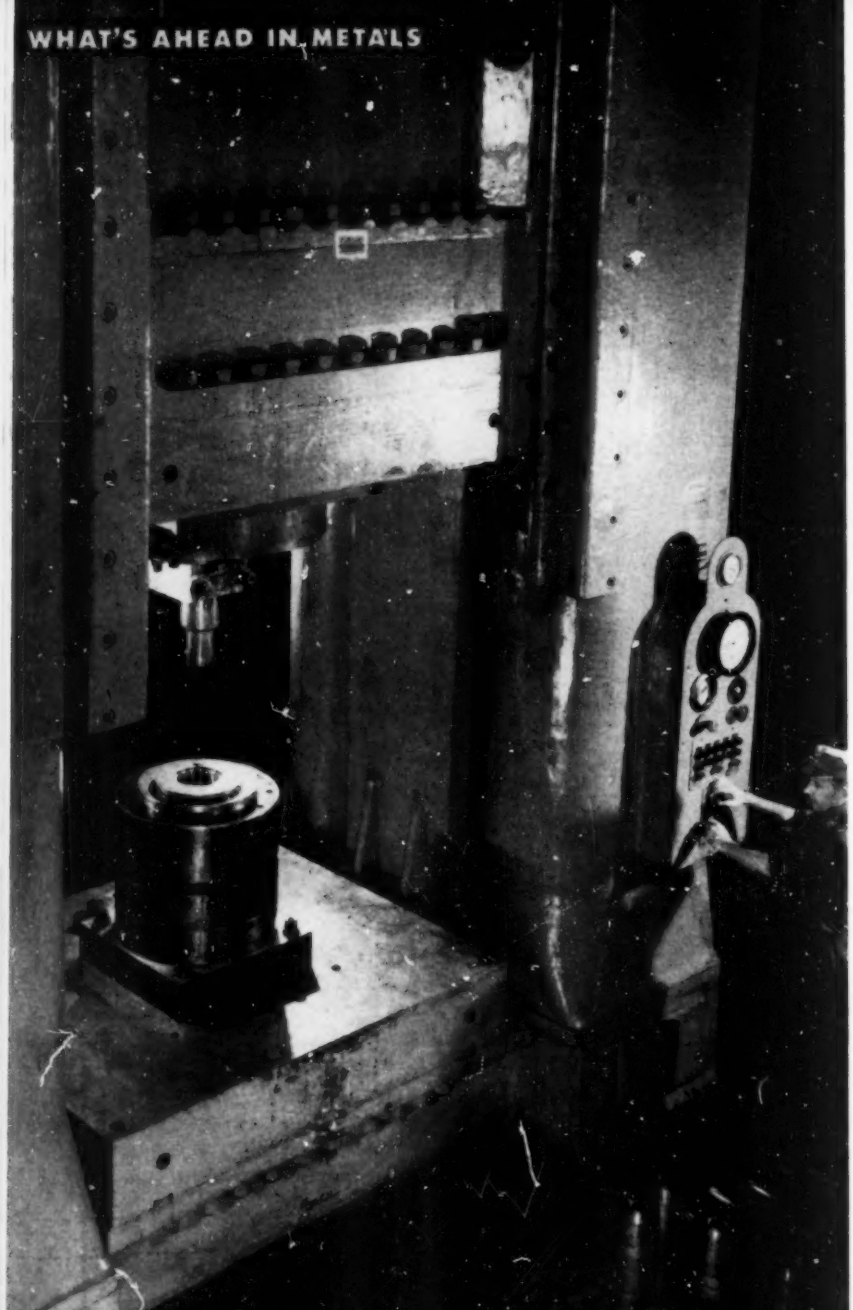
- NEW Methods of Shaping Steel
- NEW Types of Metals—for high temperature and structural uses
- NEW Metal-Ceramic Combinations
- NEW Stainless and Alloy Steels
- NEW Light Metal Alloys
- NEW Production Techniques, including
  - . . . "precision" casting methods
  - . . . vacuum melting and casting
  - . . . extremely large pressure forgings
  - . . . welding of new metal combinations.

Cold Extrusion of Steel

One of the major developments of the half century is cold extrusion of steel on a practical basis. If present trends continue, many design concepts in steel shapes will change radically. Developed from an original German process, Army Ordnance is actively pushing research and pilot plant operations in at least two plants in this country. Right now military applications are for 105 mm howitzer shell and cartridge cases which are cold extruded from hot rolled bar stock.

Although punches and dies are used in cold extrusion, it differs basically from drawing. During drawing the workpiece is formed by the application of tensile stresses, whereas in extrusion the piece is forced to flow as a result of applied compressive stresses. The new process utilizes both forward and backward extrusion. In backward extrusion the metal is forced to flow in a direction opposite opposite to the travel of the punch, converting a solid cylinder into a cup. During forward extrusion, the steel flows out of the die ahead of the punch at a greater speed than the ram is traveling. Success of the technique is attributed directly to the use of a crystalline metal phosphate coating that provides a durable lubricant film.

Immediate advantages are ap-



Machine Manufacturing Corp.

Cold extrusion of steel is accomplished on special hydraulic presses, such as the 3,000-ton long-stroke high speed machine, above. Shown below is sequence of shapes in forming 57 mm shell from 2 lb billet of hot rolled AISI 1010 steel. Close control of dimensions is possible.

parent: There is an extremely great saving in material. For instance, by forging, one million tons of scrap were produced in making one hundred million shell cases, while by cold extrusion only 40,000 tons of steel scrap were produced. There is also a saving in machine operations, as well as a tremendous saving in labor. One operation can reduce a cross-sectional area by as much as 80 percent. Where drawn cartridge cases were made from plate, disk, cup and then deep drawn in several operations, the present process starts from a bar, in itself a cheaper item. In forming the first piece, only the width of a bandsaw cut is lost, whereas customarily a yield of only 50 percent resulted from cutting disks from plate. In addition, the usual spheroidizing annealing treatment is eliminated.

Perhaps the most important advantage is the increase in physical properties. Pieces obtained by this process from plain carbon steels show tensile values ranging from 95,000 to 120,000 psi. Increases in tensile strength up to 70 percent are possible. There also seems to be an increase in elongation from a cold extruded structure, compared with that normally found by cold-drawing to the same tensile.

Present size limits seem to be about 15 in. in length, with length-diameter ratios varying from 4:1 to 24:1. Larger size parts are envisioned. Also, it is planned to extend the process to higher carbon and low alloy steels.

Large-Scale Forging and Extrusion

The armed services are sponsoring a good deal of research and pilot plant operations to make a realistic possibility many production process which have been

Army Ordnance Dept.

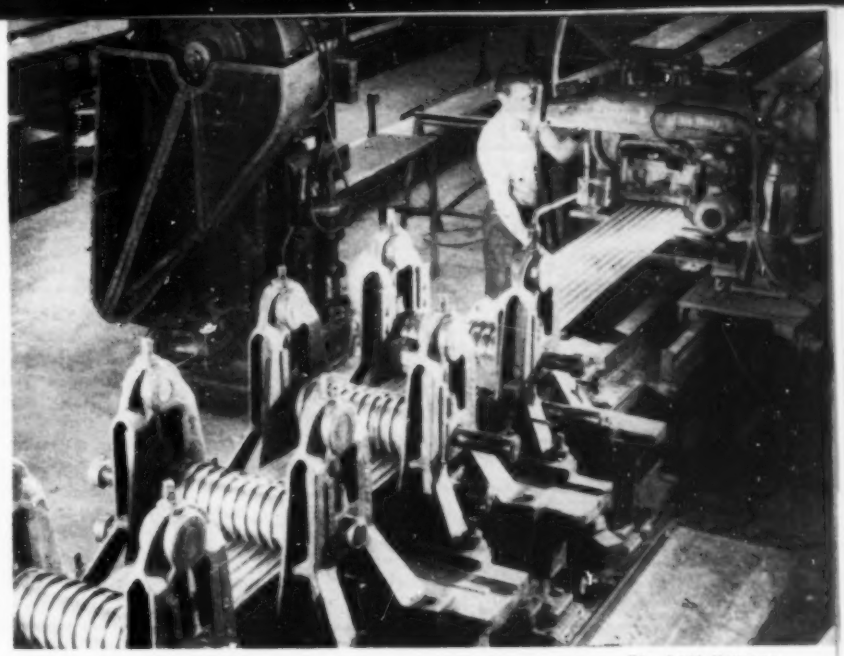
merely talked about for a long time.

One of the most noteworthy attempts in this direction is the U. S. Air Force Manufacturing Methods Pilot Plant, operated in conjunction with the Gerity-Michigan Corporation at Adrian, Mich. This plant has as its object the taking of large scale drawing, forging and extruding operations out of the theoretical stage and into the practical production stage, and promises to have a far-reaching effect on the entire national industrial potential.

Extremely large hydraulic forging presses from Germany are now being installed and are expected to be in full-scale operation by the end of the year. One such machine is a forging press of 15,000 metric tons, which when in operation will be one of the largest forging presses in the United States. A 30,000-ton hydraulic press, believed to be the largest in the world, was obtained by Russia from Germany just after the last war; it can be assumed that this hydraulic press is not standing idle.

Typical of the type of thinking which is sparking the Adrian plant, is the production of high strength lightweight aircraft parts. For instance, spar caps which were formerly assembled from several components including the root, inboard and outboard ends, proved to be inefficient, uneconomical and time-consuming in production. The spar caps are now produced in one operation, and more than 1,000 lb of metal are saved, because of the extremely small amount of waste. About 300 hr of manufacturing time were also saved. This particular part happens to be a forging, but the same type of analysis can be applied to extrusion and cold-shaping.

The Adrian plant is also experimenting in improved extrusion techniques. Such metals as pure beryllium and high alloy steel have been extruded successfully. Investigations are now being made in the extrusion of titanium, pure molybdenum and steel alloys in various shapes and tubes. This plant contains one of the largest extrusion presses in the United States, having a total force of 5,500 tons. By using such large extrusion presses



The Budd Company

Ribbons of stainless steel are formed by this machine into corrugated strips. Roof sections of new all-stainless passenger railroad cars are formed from 85-ft strips welded together. Roll forming contours the strip.

fatigue strength of materials in large sections have been improved immeasurably.

The Air Force is not making any restricted selection of products or methods to be studied. Anyone using the plant merely pays for actual development time, but no capital investment cost is involved. Now under study at Adrian is a 75,000 ton hydraulic forging press, which will be six stories high. Such a press could forge a wing stabilizer, for instance, with one die.

Stainless Steels

Use and production of conventional stainless steels are increasing steadily and important new developments are proceeding apace.

THE TANTALUM-BEARING STAINLESS. One of the most important new developments in this field both from industrial and military points of view is the production of tantalum-bearing stabilized grades of steels. Although some tantalum has always been present in the columbium stabilized grades, the present impetus for its wider increase in Type 347 formulations is specifically the increased demand for this alloy for high-temperature service.

The need for a special element to stabilize austenitic grades of stainless steels (Cr-Ni) has been known for some time. These materials are subject to intergranular corrosion after they have been sensitized in a temperature range from 800-1500 F. Columbium has answered this need in the Type 347 material. Also in the so-called "super alloys", columbium was found most effective to maintain strength at high temperatures.

Columbium ores rich in tantalum heretofore unused are now being processed in an effort to expand the supply of columbium. A new iron-tantalum-columbium (40-20-40) alloy has been developed for introducing columbium plus tantalum into high temperature alloys ("super alloys"), and the Type 347 grade of stainless steel. In the "super alloys", tantalum can be substituted for columbium, point for point, with equal effect, whereas in the Type 347 stainless steel, it has been found that two points of tantalum are required to replace one point of columbium to stabilize the steel. Several commercial heats have been made using the ferro-alloy containing the 2:1 ratio of columbium to tantalum, and they have been fabricated into heat and corrosion-resistant products.

LOW CARBON STAINLESS. Perhaps an even more significant development in this field is the production of extra-low-carbon grades of stainless steel having a carbon content not over 0.03 percent. These are mainly Types 304 and 316 which were made economically feasible in most instances by the use of oxy-

COLUMBIUM SITUATION

Columbium is an alloying agent that has acquired strategic importance in the last decade. Columbium is now being allocated, in the form of ferro-columbium, to producers of stainless steels and high temperature alloys. Measures are being taken to extend available supplies, and to supplement columbium use with other alloying agents, principally tantalum.

Nigeria is the largest producer of columbite ore, as a by-product of tin mining. Imports at the end of World War II dropped sharply when the accumulations in Nigeria were depleted, but for the past two years the normal production of columbium ores has been increasing. Also, installations of mechanical equipment now being made and planned will appreciably increase the production in the years ahead. Expanded British production of high-temperature alloys has taken more of Nigerian columbite. Belgian Congo production of columbite has grown rapidly in the last few years, but Congo ores are lower grades. However, they can be beneficiated as a satisfactory source of columbian and tantalum.

Columbite ores with the high tantalum content, available from South America and other strategically favorable locations, were not heretofore useful. But the utilization of tantalum as a substitute for columbium in many alloys is rapidly changing this picture.

Stainless steel can also be stabilized with titanium. The cost of ferrotitanium is lower than ferrocolumbium, and there is an abundant supply, but titanium is not a satisfactory substitution for columbium in many instances.

Columbium conservation also lies in wider use of the new extra-low-carbon stainless steels.

gen for decarburizing the molten metal in the furnace and the development of the extra-low-carbon grades of ferrochromium.

These materials have many advantages especially in economy. For instance, the extra-low-carbon grades of Types 304 and 316 can often be substituted for stabilized grades. They can be used as welded and stress-relieved structures in place of the austenitic steels which formerly required columbium or titanium to be added as stabilizers. However, the extra-low-carbon grades are not as foolproof as the columbium stabilized grades when used continuously at high temperatures.

The low carbon 18-8 materials with and without molybdenum may replace the stabilized types for applications in the as-welded conditions that involve short heating time in the sensitizing temperature range, 800-1500 F, or equipment which is of such a size that it is necessary to stress relieve it for periods up to two hours in the dangerous temperature zone. Test samples of extra-low-carbon stainless steels sensitized in the dangerous temperature zone for periods in excess of that which would be obtained in either the as-welded or stress-relieved conditions show no evidence of intergranular corrosion after subjecting to 240 hr in the 65 percent boiling nitric acid test. Similar successful results were obtained after boiling 500 hr in the Strauss copper sulphate test.

Before low carbon stainless steels were developed, it was often necessary to anneal stainless weldments or use more expensive "stabilized" grades to prevent corrosion attack at the weld area. Removal of the necessity for stainless steel stabilized by the additions of columbium not only results in economies for the fabricator, but also conserves the supply of columbium. Elimination of the necessity for annealing welds has permitted fabrication of large assemblies on the job, and in many cases greatly simplified the problem of field repairs on stainless steel equipment.

PRECIPITATION-HARDENING STAINLESS. These new materials are another important development in the stainless steel field. After cold-rolling or cold drawing, precipitation hardening materials require only one heat-treatment. Heavy cold reductions followed by the precipitation-hardening treatment result in extremely high tensile and elastic properties. One of these materials has the nominal analysis of 17 percent chromium and 7 percent nickel, and contains aluminum as the precipitation-hardening element. This was especially developed for sheet, strip, plate and wire applications requiring good corrosion resistance, combined with extremely high mechanical properties. Another material, containing 17 percent chromium and 4 percent nickel, employs copper instead of aluminum as the precipitation hardening element. This material is suitable for bar and billet forging applications.

Steels with normal tensile strengths of 90,000 psi, having an elongation of perhaps 50 percent, by the precipitation hardening treatment are increased in strength up to 150,000-175,000 psi. Such a treatment might reduce the elongation to about 10 percent, but this is still within the fabricating range. Indication of applications for these materials are for such products as valve parts, which require extreme hardness, high strength and dimensional stability.

"Super Alloys"

New and expanded uses of the so-called "super alloys" developed mainly for high temperature use during and shortly after the last war, are becoming increasingly significant. Instead of small experimental amounts, large volumes of such materials are being used.

COMPLETELY NEW TYPES. Latest requirements for high strength at high temperatures has increased the demand for radically new types of alloys, some of which are entirely out of the ferrous field, or contain iron in relatively minor amounts. Requirements of the armed services for extremely high temperature resisting parts are being met primarily by these types of alloys which contain large amounts of chromium, titanium, molybdenum, and cobalt.

Under Navy sponsorship, research at such institutions as the Massachusetts Institute of Technology and the Battelle Memorial Institute has indicated two chromium alloy types as having promise

for structural high-temperature 1,600-1,800 F uses. One is a chromium-molybdenum-iron type, and the other a chromium-molybdenum-nickel type. The system chromium-molybdenum-iron, having the approximate analysis 60 percent chromium, 25 percent molybdenum and 15 percent iron, has extremely high resistance to stress rupture at high temperatures. Both of these materials are fairly brittle at high temperatures, but addition elements are expected to reduce this effect to a great extent. At present they are being used experimentally in castings only, but forging grades are hoped to be developed.

Molybdenum- and titanium-base alloys (see "New Structural Metals" by J. J. Harwood, following this article) offer even greater promise in the high temperature field, because they can be produced in sheet, strip, tube and rod forms, as well as in forging grades. However, the molybdenum-base alloys oxidize above 1,300 F, and require coatings, such as ceramic enamels, or a silicon material which combines chemically with the molybdenum.

Improvements in the titanium alloys are being accelerated. Titanium tubing, for instance, is now a reality. It is produced from strip which is formed, welded and then drawn into sizes ranging from 1½ x 0.075 in. wall to ⅛ in. OD x 0.010 in. wall in lengths up to 10 ft. Some seamless tubing has been made by drilling and cold drawing bars. Cold drawing titanium is made difficult by its tendency to gall and seize to the drawing dies, and a new scheme of lubrication has had to be devised.

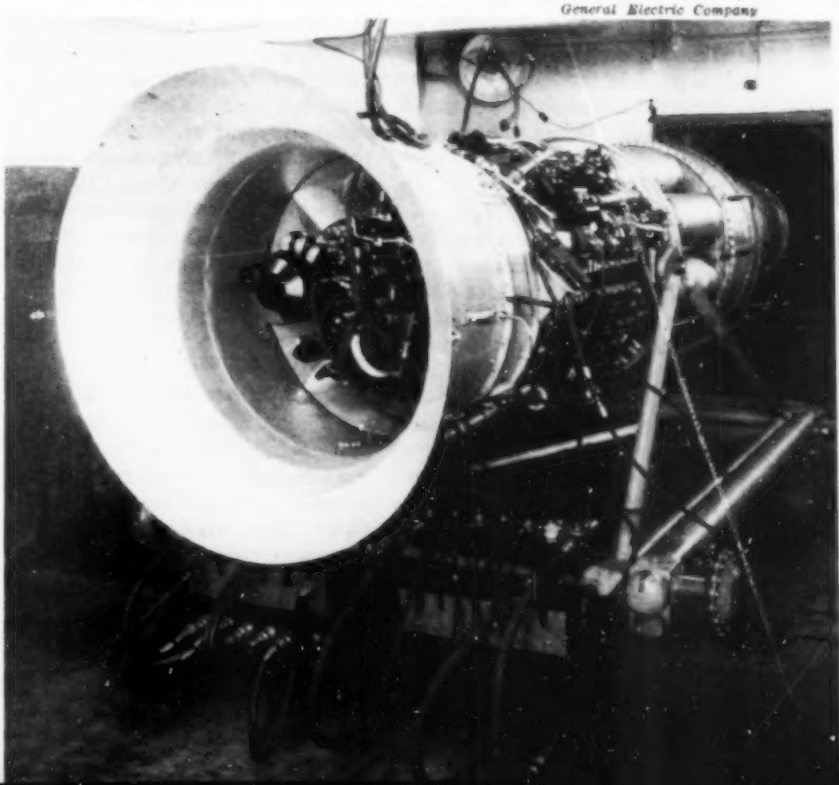
To avoid the embrittling effect of oxygen, nitrogen, carbon and hydrogen, at elevated temperatures, titanium is annealed in vacuum or inert atmospheres. Oxygen and nitrogen can be used under rigidly controlled conditions to surface harden titanium.

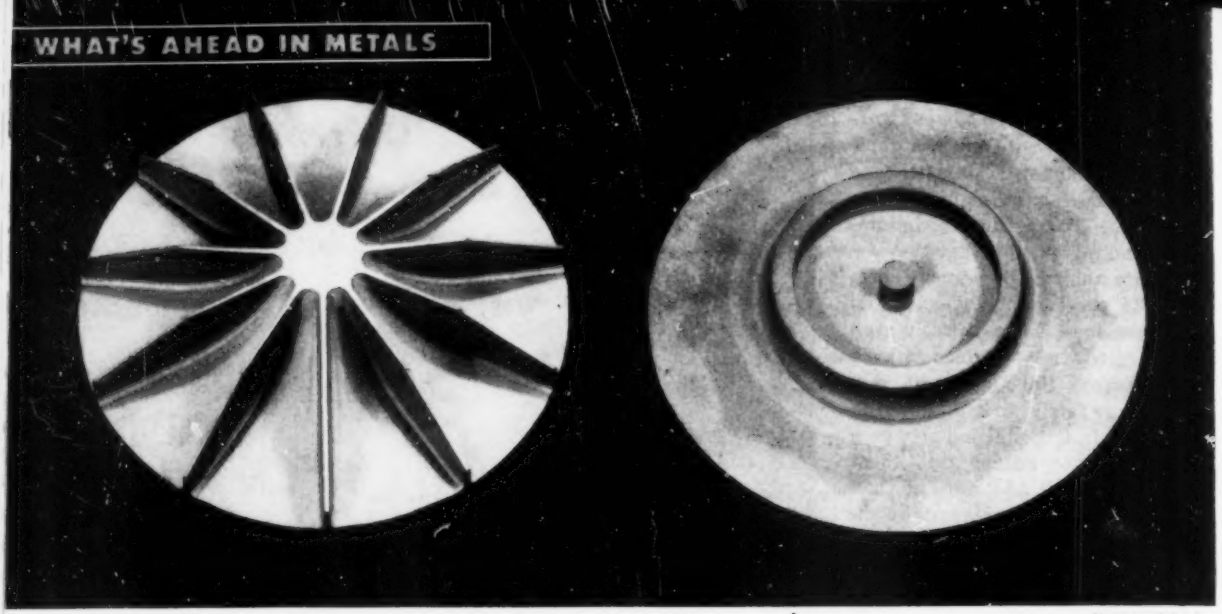
As the methods of producing titanium metal improve, embrittling elements are reduced, and the strength of the resulting metal decreases with an improvement in ductility. This is desirable for fabrication of shapes, especially tubing, and may permit the use of titanium for aircraft hydraulic

Boeing Airplane Company

New types of stainless steel, "super alloys", high temperature metals, and high strength titanium and light metal alloys are all used to construct modern jet engines and aircraft. Shown above is B-47 Stratojet.

General Electric Company





Kennametal, Inc.

Two views of gas turbine impeller made of metal-ceramic "combination". This material consists basically of titanium carbide with 20 percent cobalt, and is enlarging the scope of high temperature design.

lines, and by the chemical industries for handling wet chlorine gas, nitric acid, salt solutions and fruit acids.

At present almost all of the significant applications of titanium are being made to aircraft. Forged jet engine rotors, compressor blades and disks, and skinning around high temperature elements of aircraft where stainless steel formerly was used now are being made of titanium, because of the weight saving involved. Indication of the major inroads into the stainless market is the tie-up by several steel producers with concerns who have been active in the development of titanium and titanium-base alloys. Allegheny-Ludlum and The National Lead Company have a working agreement through Titanium Metals Corporation of America, and recently Crucible Steel tied up with Remington Arms, which was one of the first in the titanium alloy field, to form a joint company.

The Navy Bureau of Aeronautics is sponsoring development of a 3 percent aluminum—5 percent chromium—titanium alloy, which appears to have promise as a commercial material in hot forged and possibly sheet forms.

A cobalt-base alloy for use in sheet-metal components of gas turbines has been developed. It consists of cobalt (50 percent), chromium, nickel, and tungsten, has high strength resistance up to 1,800 F, and resistance to oxidation and carburization up to 1,900 F. Weldability is satisfactory, and good workability is obtained in fabrication. The new alloy is nearly comparable in formability with N-155 alloy and Type 347 stainless steel. Numerous aircraft sheet-metal parts—small fabricated blades to larger afterburner assemblies—have been fabricated from the alloy. Deep drawing, spinning, stamping, drop-hammer forging, and similar operations have been successfully carried out with this material. Welding has been performed with roller seam, spot, heliarc, and electric arc methods with comparative ease.

Another relatively new cobalt-base alloy is finding use as a spring material, both at normal and elevated temperatures. It contains 40 percent cobalt, 20 percent chromium, 15 percent nickel, about 15 percent iron, 7 percent molybdenum, and small amounts of manganese and beryllium. Corrosion-resistance of this material is outstanding.

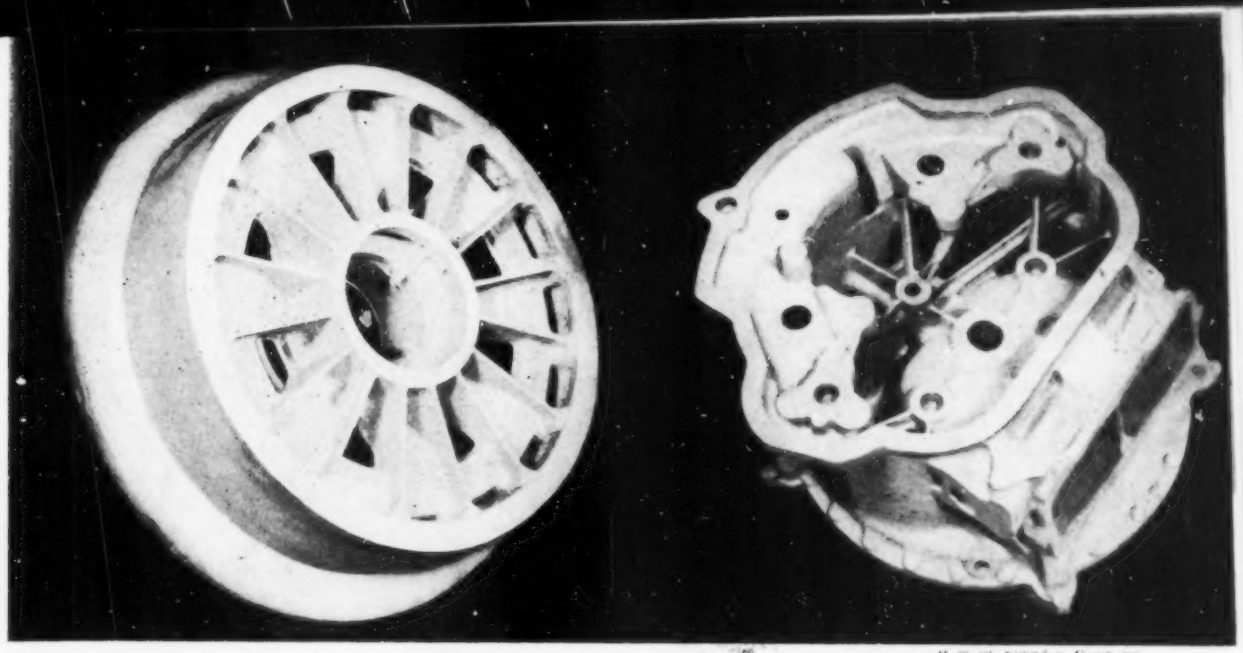
Metal-Ceramics

It is not a far step from cobalt to "non-metallics". Experts believe that about 2,000 F is the top temperature limit for highly stressed parts in "purely" metallic alloys. For higher temperatures, ceramics, ceramic-metal combinations, or ceramic-coated metals are indicated.

New "metal-ceramic" compositions combine the thermal shock resistance of alloys with the high temperature strength of ceramics. One such material is titanium carbide. Two cemented titanium carbide compositions, each containing approximately 20 percent cobalt, are particularly interesting. Tensile strengths at 1,800 F are higher than those of any high temperature alloys or ceramics. Specific gravities are about two thirds that of steel so that on a strength-weight basis the tensile values become very high. Their low thermal expansion and high thermal conductivity help increase the thermal shock resistance. This material is powder-pressed (molded) or extruded into such shapes as turbine blades, bushings, nozzles and valve seats.

Another new commercial "ceramet" or "metamic", as they are variously called, consists of fused aluminum oxide bonded with chromium metal.

MAGNETIC FERRITES. Marketed under the trade name "Ferramics", these are a relatively new family of magnetic materials. Chemically they consist of various oxides of metals such as Fe_2O_3, MnO, ZnO and NiO, combined in a "spinel" structure. They exhibit many of the mechanical properties of other oxide bodies, such as porcelain or steatite. They are semi-conductors having very large volume resistivities, of the order of 10^5 to 10^8 ohm-



Zirconium, zinc, and "rare earth" metals are extending magnesium's range of applications. Aircraft wheel and engine part are made of "Z5Z", a magnesium-zinc-zirconium alloy with high strength-weight ratio.

cm, and at the same time being strongly ferro-magnetic in nature.

The "ferramics" fill a gap in the frequency spectrum, between laminated iron alloys used at power frequencies to handle large amounts of power, and powdered iron cores used at high frequencies to handle relatively low powers. They can be used in applications at audio frequencies and up into the high megacycle range at medium power levels. Such cores are now used in television circuits.

New Magnesium Alloys

The search for lighter-weight, higher-strength alloys is just as urgent as the search for new high-temperature materials. These high strength-weight ratio materials are envisioned not only for aircraft and other parts where lightweight is a "must", but for many military vehicles, which in a modern war can be carried by air. Completely new types of magnesium alloys promise to meet this need.

Mechanical properties of sand-cast parts of new magnesium-zinc alloys look quite promising. The tests show that many of these alloys show greater resistance to creep at elevated temperatures than that of present commercial magnesium alloys.

Other magnesium alloys of promise are magnesium-zirconium, magnesium-lithium, and magnesium-cerium. The magnesium-cerium alloys look promising for "intermediate" temperature structural uses.

The metallic element cerium is in the "rare earth" category. Many of these magnesium-rare-earth-metal-zirconium alloys use for their "rare" component a material known as "Mischmetal", a typical analysis of which is 50 percent cerium, 20 percent lanthanum, 18 percent neodymium, 6 percent praesodymium, and lesser amounts of other elements of this group. These magnesium-"rare earth" alloys look extremely promising, especially when produced as sand castings. Immediate applications are for aircraft engine parts operating at temperatures up to 600 F.

An alloy of particular promise, which is being investigated by the Engineer Research and Development Laboratories (Army) at Fort Belvoir, Va., is a magnesium-zinc-zirconium-silver alloy, in which is present 6 percent zinc, 0.6 percent zirconium and 6 percent silver. This yields tensile strengths up to 60,000 psi, yield strengths up to 40–45,000 psi, and elongations up to 10–15 percent. One possible use for this alloy is for airfield landing mats.

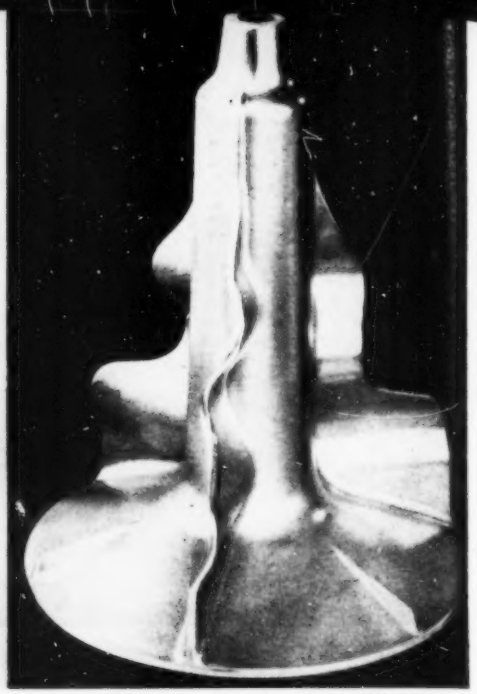
Magnesium-lithium alloys are still in the developmental stage. Their attractive properties include densities equal to or lower than magnesium itself, strength-weight ratios equal to the strongest aluminum alloys, and in some compositions, greatly improved cold-rolling and cold-forming characteristics, compared to present commercial magnesium alloys.

The magnesium-lithium alloys are used with zinc and/or aluminum. These alloys usually contain 10 to 15 percent lithium, about 5 to 10 percent zinc and/or aluminum. More laboratory work is required to overcome certain deficiencies in these alloys.

NEW MAGNESIUM EXTRUSIONS. One of the most promising of the new alloys have already been put into use. This is known as the ZK60A alloy, and contains 5.7 percent zinc and 0.6 percent zirconium. It is an improved extrusion alloy, which has improved strength toughness and resistance to notch-sensitivity. This combination of desirable properties is attributable largely to the presence of zirconium in the alloy. In addition to aircraft applications for which it is already being used, other commercial prospects include truck and trailer floor sills and related parts, textile machinery and materials handling equipment.

A new production technique which, it is planned, will greatly broaden the applications for magnesium alloys, is the extrusion of powdered magnesium alloys. By using this technique in combination with heat-treatments, high tensile strength magnesium alloy shapes can be produced which are impossible by ordinary extrusion or powder-metallurgy methods.

Non-Ferrous Perma Mold, Inc.



Monarch Aluminum Mfg. Company

Permanent mold casting now makes possible large scale production of precision parts in a wide variety of metallic alloys. At left, group of copper-base alloy castings, produced in weight range from ½ oz to 35 lb. At right, washing machine agitator cast of aluminum has a smooth, hard finish that is a commercial asset.

NEW MAGNESIUM FINISH. A new organic lacquer, developed at Princeton Paint Laboratories, Inc., gives magnesium parts effective surface protection by a method which is commercially feasible.

Aluminum Alloys

A development representing an immediate "big step forward" is the extrusion of aluminum alloy ribbed sheet. After extruding the shape, it is straightened by stretching it slightly past the elastic limit. Then it is slit to open the circular cross section. A flat sheet is subsequently obtained by a series of operations to open the circle and flatten it out. By ordinary methods, a very thick plate of aluminum is milled out, leaving only a thin sheet with its reinforcing ribs. In time of emergency, any volume of ribbed sheet would simply require more aluminum than would be available, because of the tremendous waste in milling.

A similar advance is the rolling of aluminum alloy "tapered" sheet for aircraft construction. This type of sheet speeds production of complicated sections, decreases waste, and permits "closer" design.

A new forged aluminum disk wheel is to be marketed for truck, trailer and bus use. The wheels are commercially available in both the 7.50 x 20 and 7.50 x 22 in. sizes. Every pound saved by using the aluminum wheels can be replaced by a direct increase in pay load without exceeding maximum axle loading.

Other new developments include a new aluminum die-casting alloy with 4.3 percent silicon, 1.8 percent magnesium, 3.5 percent of zinc; and an aluminum-coated steel-core wire, which is replacing the usual zinc galvanized core for short transmission lines, which operate at approximately 460 volts.

Copper-Base Alloys

Recently announced by one large brass producer is the casting of brass cakes in weights over 3,000 lb, making available finished brass in coils up to 24 in. wide, and weighing as much as 100 lb per in. of width.

Also being produced by the same manufacturer is a new brass especially adapted for drawing and stamping operations, and characterized by exceptionally fine grain, ductility, resistance to abrasion, and surface smoothness that greatly reduces buffing and polishing coats, with reported savings up to 35 percent.

New bronze die alloys offer great advantages for such uses as deep-drawing of stainless steel. One such alloy in particular, because of its intermetallic structure—minute hard particles uniformly dispersed in a softer matrix—gives dies of longer life, freedom from galling and scratching, and decreased maintenance time.

"Rare" Metals

Production of practically pure tungsten on a commercial basis makes available a metal for use wherever maximum density, mass or inertia is required in limited space. Produced by machining from standard shapes or by powder metallurgy methods, the material can be used for rotors, flywheels, governors, and balance weights. Up to the present time, the only use of tungsten has been in the lamp and electronic tube industry.

Availability of the metal germanium, which is a semiconductor, has led to its use as diodes in photocells and television receivers. Compactness and high sensitivity reduce size of such units, by operating relays without electronic amplification.

Vacuum Techniques

Production of high purity metals, both for research and actual use, has been accelerated by vacuum melting and casting techniques developed by the National Research Corporation. One of the most promising uses of vacuum melting is in the production of

large copper castings used in applications where maximum electrical conductivity is required. It is actually possible to achieve conductivities as high as 100.3 percent IACS. Large castings can be made with comparative freedom from difficulties caused by gas pockets. Such components include gas free high-purity copper anode blocks which are used in large power tubes. Gas would interfere with evacuation of the large power tubes in which the components are incorporated. Rough castings weighing several hundred pounds are finish-machined and drilled to extremely close dimensional tolerances.

NEW METALS. The use of vacuum melting techniques is of particular interest in problems associated with the production of titanium and zirconium. Titanium sponge produced by the Kroll electrolytic process is most successfully converted into ductile ingots by melting at low pressures or in inert atmospheres. Purified hydrogen and argon atmospheres can be very expensive in large scale operations. Actually the use of high vacuum here is an economy, when compared to the use of large quantities of carefully processed inert gases.

HEAT TREATING. Manufacturers are now annealing watch springs in vacuum to achieve bright surfaces and reduce embrittlement caused by reaction of gases on the surfaces of the finished products.

Powder Metallurgy

New developments in the important powder metallurgy field include use of metal powders to make bearings, bearing plates, odd-shaped gears, clutches, ratchets, cams, as well as special applications such as: Copper combined with steel so that the copper would melt when the steel was shaped to produce a self-brazing part; lead dispersed in copper to provide bearing properties; oil-impregnated pieces, in which the powder metal part, because of its porosity, acts as a permanent oil reservoir.

Combinations of powders are now used: Copper combined with carbon for brushes; silver combined with tungsten contact points; and mixtures of copper, tin, iron, lead, graphite, and silica to produce heavy-duty friction surfaces.

Powder metallurgy parts are now successfully plated. Usually applied to sintered iron parts, plates include nickel, copper, and silver. The same coatings can be applied to brass and bronze parts.

New Casting Methods

Probably the most exciting news of the year in the casting field is the "C" process, which employs a special phenolic resin binder for producing cores and molds from sand. Although resins have been used for many years in sand core binding, the new method uses as a mold only a thin "shell" of sand. Some of the advantages claimed for the process are as follows:

1. Excellent dimensional accuracy. Tolerances between 0.001 and 0.003 in. per in. have been claimed.
2. Excellent surface finish, obviating necessity for many cleaning and machining operations.
3. Better metal yield.
4. Greatly increased production.
5. Ability to cast very thin sections.
6. Greatly reduced sand-to-casting weight ratio, thus cutting costs.

A new method for producing precision castings is the "Mercast" process, which consists of the following steps: (1) Liquid mercury is poured into a master mold made of metal or other material; (2) the mercury-filled mold is chilled in a bath at a temperature below −40 F; (3) frozen mercury pattern is then removed from the master mold. With a complex product, a number of component patterns can be built into a complete pattern; (4) the frozen mercury pattern then is dipped in a chilled refractory slurry made up of very fine ceramic particles. Several coatings are given the part, until it has a ceramic shell of from ¼ to ½ in.; (5) when the shell-like mold is thoroughly dried in a cold box, the mold is removed to room temperature where the mercury melts out, and later fired in a kiln; (6) conventional pouring or centrifugal casting is the next step. The mold "breathes" to allow air and gases in the molten metal to escape, preventing blow-holes. (7) When cool enough to handle, the thin ceramic mold is broken from the casting. This process lends itself to production of complicated parts.

Produced by "Mercast" process, this 3¾ x 3¾ in. gear-cutting hob is cast of Tantung and other abrasion-resisting alloys. Now on life-run test, this type of hob is widely used in automotive industries.

National Bronze and Aluminum Foundry Co.

New Structural Metals

J. J. HARWOOD, *Office of Naval Research**

MOTIVES BEHIND the intensified search for new metals are two-fold: (1) Depletion of vital metals, especially such elements as chromium, manganese, nickel, tungsten and vanadium, is an ever-growing threat to the national security; and (2) the increasing demand for high strength, lightweight, and heat-and corrosion-resistant materials, resulting from accelerated technological developments of the last decade. Requirements of jet engines, atomic power plants, gas and steam turbines have led to the realization that mere improvements in conventional metal systems cannot solve the host of new problems that have arisen.

This search for new types of materials has been concentrated on a group of metals formerly used mainly as steel alloying ingredients. Known as the "refractory metals" because of their high melting points, this group includes zirconium, titanium, columbium, molybdenum, tantalum, tungsten and chromium. Table I lists melting points and densities of these and the more commonly used metals. Because of their potentially outstanding properties, titanium, zirconium and molybdenum have been singled out for industrial consideration as the base or major elements of completely new types of metallic alloys. Availability is another consideration.

TITANIUM

PRODUCTION of ductile titanium has assured the future position of this metal as an engineering material. Its desirable properties, including lightweight, excellent corrosion resistance and outstanding strength-weight ratios were covered in a comprehensive survey published in the November 1949 issue of PRODUCT ENGINEERING. New data have been reported which fill out the picture of titanium's usefulness.

PROPERTIES. One type of annealed titanium sheet showed room temperature creep at all loads corresponding to C0 to 90 percent of the yield strength. Cold rolling improved the creep behavior; creep became negligible at loads corresponding to 80 percent of the yield strength. Thus, in designing with titanium for high duration static loads, yield strength cannot be considered alone. Curves of the type used for high temperature design should be determined.

This creep behavior is, however, characteristic of most pure metals. Most applications of titanium require a cold worked condition and do not involve loads so close to the yield strength as to produce creep. In addition, titanium alloys which will be predominantly used, exhibit more favorable creep behavior than the commercially pure metal.

Titanium apparently exhibits a transition from brittle to ductile behavior, similar to steel. However, the relatively high temperature of this transition makes it appear that titanium may be undesirable for applications where toughness is the primary requisite. Fig. 1 shows the effect of temperature on notch strength of a high strength alloy.

It is now established that cast and worked titanium specimens exhibit the highest endurance limit-tensile strength ratio of all known structual materials. Flexural fatigue tests of unnotched titanium bars show fatigue strength (10^7 cycles)-to-tensile strength ratios of 0.8 at room temperature. Ratios for steel are from 0.45 to 0.55. In addition, the fatigue strengths themselves are comparable to those for steel.

Titanium forged from cast ingots has been observed to have a marked response to understressing. For example, a specimen started at 40,000 psi was raised 2,000 psi every 20 million cycles, up to a stress of 80,000 psi without failure.

Compressive stress-strain properties of commercially pure sheet up to temperatures of 800 F, with exposure times from ½ to 2 hr, are reported to be most favorable for aircraft structural use. Compressive yield stress and modulus of elasticity hold up quite well from 200 to 800 F (Fig. 2); in fact at 800 F the yield stress in compression is higher than values which had been published for tension. At all temperatures compressive properties in the longitudinal direction are markedly below the transverse properties. This large directional effect decreases with increasing temperature. The compressive strength of titanium sheet depends also on the amount and kind of cold work performed on it.

Another outstanding property of titanium is its exceptionally high resistance to corrosion in marine environments. Rotating spindle tests in sea water at speeds of 1,140 rpm (peripheral speeds of 26 ft/sec) for 60 days indicated negligible corrosion attack. Packing corrosion tests to determine resistance to pitting attack from common packing materials have also been conducted. After 46 day tests in brackish salt river water, no deleterious effects were observed, (Fig. 3). Stress-corrosion tests, conducted under tensile loads of almost 95 percent of the yield strength in similar environments, produced no failures over a six-month period. Titanium specimens also satisfactorily withstood stack gas (about 200 F) corrosion tests. Corrosion fatigue resistance in brackish sal

Table I—Melting Points and Densities of Metals

Metal	Melting Pt., F	Density g/cc	Density lb/cu in.
Magnesium	1,200	1.74	0.0628
Aluminum	1,220	2.70	0.0975
Copper	1,981	8.96	0.324
Iron	2,800	7.87	0.284
Titanium	3,272	4.54	0.164
Zirconium	3,380	6.5	0.230
Chromium	3,430	7.19	0.260
Columbium	4,380	8.57	0.310
Molybdenum	4,750	10.2	0.369
Tantalum	5,425	16.6	0.600
Tungsten	6,170	19.3	0.697

* This article represents only the personal views of the author and in no way reflects the official attitude of the U. S. Navy Dept.

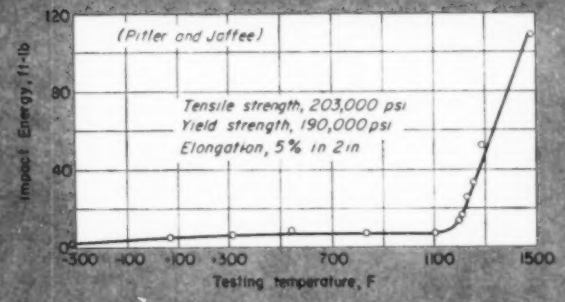


Fig. 1 — Impact strength (V-notch Charpy) of a high-strength titanium alloy (4.6 Cr, 3.1 Al, 0.49 C) varies with temperature.

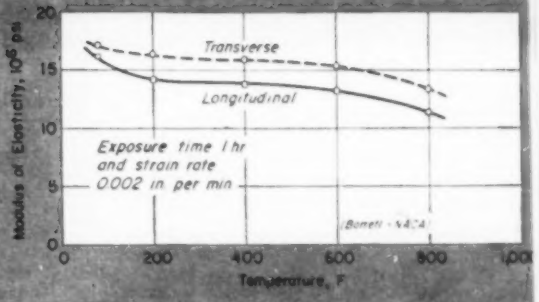


Fig. 2 — Variation of modulus of elasticity in comparison with temperature for 20 percent cold worked titanium sheet.

water was greater than that for any other known structural alloy. At 55,000 psi the tests were still running after 90 million cycles, whereas for K Monel and a 16 Cr-2 Ni corrosion resistant steel, fracture occured at about 36,000 psi at 50 million cycles.

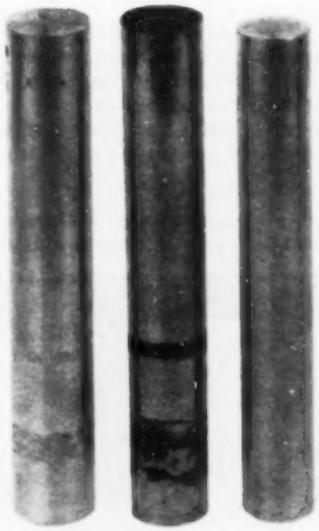
Titanium, unlike stainless steel, can be anodized in much the same manner as aluminum alloys, in either sulfuric or chromic acid electrolytes. The adhesion of paint to titanium is improved by anodizing, when the primary coat is a zinc chromate primer (AN-P-656). With a WP-1 metal conditioner as a prime coat, excellent paint adhesion is obtained on both anodized and unanodized material.

PROCESSING AND FABRICATION. Up to about 1.2 percent carbon exerts little effect on the forgeability and rollability of titanium ingots if operating conditions are suitable. Ingots containing as high as 1.5 percent carbon have been forged readily at 1,700 F, and rolling was accomplished at 1,450 F without extensive surface or edge checking, except at the highest carbon percentage. No edge cracking occured on subsequent cold reduction. There appears to be no reason why conventional forging and rolling techniques and equipment cannot be utilized for titanium if proper temperatures are maintained.

Above about 0.25 percent, greater amounts of carbon do not appreciably affect room temperature hardness and tensile strength of commercial titanium, but do cause an increase in proportional limit, modulus of elasticity, hot-hardness and oxidation resistance and a decrease in ductility.

The workability of commercially pure titanium into useful shapes is established. Both seamless and welded and drawn titanium tubing are being produced. Table II lists the mechanical properties of welded and drawn titanium tubing, as well as seamless 1015 steel and welded and drawn Type 304 stainless tubing. The titanium tubing is arc welded under an inert atmosphere blanket to prevent embrittlement. Welded and annealed tubing has been flattened down to a bend radius of 5T before showing a tendency to crack, and redrawn annealed tubing can be flattened wall to wall without cracking.

Currently this titanium tubing is available in sizes from $\frac{1}{2} \times 0.010$ in. wall to $1\frac{1}{4} \times 0.072$ in. wall, in all of the tempers shown in Table II. The unusual resistance of titanium to wet chlorine suggests many chemical plant applications. Titanium tubing has already been used experimentally in condenser tubes operating in salt water and in chemical plant equipment. Another anticipated use is for aircraft hydraulic lines which require light weight and ability to withstand pressures as high as 6,000 psi; stainless steel tubing is now used.



U. S. Naval Engineering Experiment Station

Fig. 3—Corrosion tests in salt river water show different effects on: (left to right) 18-8 stainless, 13% Cr steel, and titanium. Note difference in results.

TITANIUM ALLOYS. A tremendous amount of work by private companies and laboratories is underway for the development of high strength alloys possessing the other desirable features of pure titanium. Several promising alloys, including quarternary types, have been singled out for more intensive research.

Under a Navy Bureau of Aeronautics Department contract, P. R. Mallory and Company has developed an alloy of titanium containing 3 percent aluminum, 5 percent chromium, and small amounts of carbon, which has promising room temperature and elevated temperature strength properties and favorable oxidation resistance. Variations in this alloy system ranging from 2.5-3.75 percent Al, 4.3–5.0 percent Cr, and up to about 0.7 percent carbon have been investigated. Aluminum-chromium alloys of titanium can be forged readily within the range 1,650–1,725 F with typical properties of about 175,000 psi tensile strength, 155,000 psi yield strength, and 8–10 percent elongation (in 2 in.) in the as-forged condition, after an 85 percent reduction in area. Cast ingots weighing as much as 250 lb have been successfully hot forged.

The hot hardness properties of a 2.9 percent Al, 4.3 percent Cr, 0.60 percent C, 0.25 percent N, titanium alloy (as-forged) are shown in Fig. 4. For comparison, data for 0.77 percent C titanium have been plotted on the same curve. The retention of usable strength properties up to about 1,000 F for the Al-Cr alloy is readily apparent. Rotating

Table II—Mechanical Properties of Titanium and Steel Tubing

Temper	Process	Material	Tensile Strength, psi	Yield Strength, 0.2% offset, psi	Elong. Percent in 2 in.	Hardness, Rockwell
Annealed	Welded and Drawn	Titanium	85,000 max	45- 60,000	34-25	90 B, max
	Seamless	1015 Steel	60,000 max	30- 44,000	42-33	65 B, max
	Welded and Drawn	304 Stainless	100,000 max	34- 47,000	65-45	90 B, max
Half Hard	Welded and Drawn	Titanium	85-100,000	65- 80,000	6-15	80-95 B
	Seamless	1015 Steel	60- 72,000	48- 66,000	12-26	70-82 B
	Welded and Drawn	304 Stainless	115-140,000	70-120,000	18-38	95 B, 28 C
Hard Drawn	Welded and Drawn	Titanium	100-125,000	80-100,000	3-9	95 B, 25 C
	Seamless	1015 Steel	72- 90,000	64- 82,000	6-15	80-90 B
	Welded and Drawn	304 Stainless	150-200,000	115-170,000	7-20	42 C

Superior Tube Company

beam fatigue tests on a 3.2 percent Al-4.85 percent Cr-titanium alloy of 183,000 psi tensile strength have been run to 110 million cycles at a stress of 90,000 psi without failure. Fig. 5 illustrates the 500 F fatigue properties of several similar alloy compositions.

Silicon additions to this alloy increase the as-forged tensile strength and improve the hot hardness up to 1100 F. Boron additions improve the resistance to oxidation at 900 F, and in the as-forged state increase the tensile strength to 200,000 psi with a decrease in ductility to 2.35 percent elongation in 2 in. The hot hardness is also improved; a Rockwell A hardness of 31 at 1,100 F was observed. This compares with Rockwell A 22 for similar alloys without boron. Boron seems to provide desirable improvements in the Al-Cr-C-titanium alloys, if heat treatments can be found to increase the ductility.

APPLICATIONS. Large-scale applications of titanium will take advantage of its two major attributes: Favorable strength-to-weight ratio, and outstanding chemical inertness to marine environments. The numerous aircraft and ship structural components for which titanium seems to be well suited may provide the necessary demand for the large scale production of low-cost titanium. Even at its present relatively high cost, it still represents competition to many other metals for certain specialized applications. It seems a "natural" for many military applications.

For naval use, titanium's sea water corrosion resistance, high endurance ratio and high resistance to corrosion fatigue are of particular interest. These properties make it suitable for such applications as valve seats, heat exchangers, condenser piping systems, exhaust mufflers for submarine diesel engines, pump shafts, small propellers and propeller shafts, steam turbine blading and other similar components.

In jet and gas turbine aircraft, applications of titanium are rapidly making headway. Titanium has proven satisfactory for firewalls, shrouds, baffles and diaphragms. The major advantage of titanium over stainless steel for such applications is primarily in weight saving. For example, 0.015 in. sheet of stainless steel weighs 0.60 lb/sq in., whereas similar thickness titanium sheet weighs 0.35 lb/sq in. In the standard firewall test, both titanium and stainless steels satisfactorily withstand a 6 in. diameter flame impingement for at least 15 min. The temperature approaches 2,000 F at impingement point.

Another promising application of titanium alloys is for compressor blades and disks in gas turbines. Preliminary test results on the Al-Cr-Ti alloy discussed previously are promising. At present Type 410 stainless steel is used for these applications; the use of titanium alloy for disks and blades operating at 400 F would result in a 300 lb saving. Redesign would result in even further weight saving.

Several leading aeronautical companies are evaluating the fabrication characteristics of titanium and alloy sheet for possible use as airframe skins, edges of wings, and ducting of jet planes. Since it maintains strength at higher temperatures, these are logical uses.

Fig. 4—Hot hardness properties show retention of usable strength characteristics up to about 1,000 F for Al-Cr-Ti alloy.

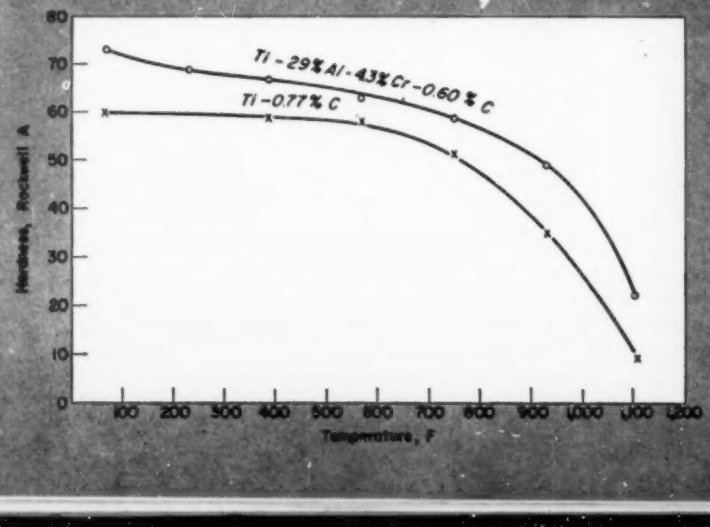


Fig. 5—Fatigue properties of several high strength titanium alloys are illustrated by "S-N" curves, developed at 500 F.

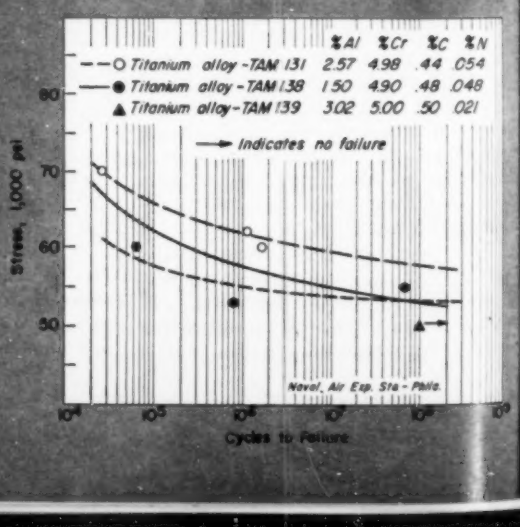


Table III—Properties of Pure Zirconium Metal

	Cold Rolled*	Annealed**	Cold Rolled and Annealed	
Ultimate Strength, psi	83,300	35,900	Melting Point	1860 C (3380 F)
Yield Strength (0.2% offset), psi	69,700	15,900	Density	6.50 g/cc
Prop. Limit (0.01% offset), psi	32,100	8,350	Specific Resistance (20 C)	41.0 microhms-cm
Elongation in diameters, percent	18	31	Coeff. of Thermal Expansion	4.96 cm/C × 10^{-6}
Hardness, Rockwell B	87.5	30.5	Crystal Structure	up to 862 C, hexagonal close packed
Modulus of Elasticity	14.5 × 10^6	11.4 × 10^6		above 862 C, body centered cubic

* Cold reduced and approximately 50 percent ** Annealed at 790 C (1450 F)

ZIRCONIUM

The development of ductile, commercially pure zirconium has paralleled somewhat the development of titanium. Methods of production and fabrication, and many chemical, structural and metallurgical characteristics are similar. While it is not anticipated that zirconium will receive the same degree of commercial use as titanium, its outstanding corrosion resistance will insure widespread use in the chemical industry.

AVAILABILITY AND PRODUCTION. Zircon sands, which are the basic ingredient for the production of zirconium, are abundant in Florida and the Pacific Northwest regions. The U. S. Bureau of Mines has established a pilot plant process for the production of zirconium which is capable of producing 300 lb per week of malleable zirconium. A typical analysis of a zirconium heat is as follows: C 0.15 percent, Fe 0.05 percent, N 0.01 percent, Hf 1.5 ±0.3 percent. Thus, all following properties and discussion actually pertain to a zirconium-hafnium alloy and not to pure zirconium.

PHYSICAL AND MECHANICAL PROPERTIES. Properties of pure zirconium metal made by the iodide process (not same as Bureau of Mines process) are listed in Table III. Pure zirconium is about 45 percent more dense than pure titanium, and does not show as good yield strength-tensile strength or strength-weight ratios. Its strength-weight ratio is also lower than those for high-strength aluminum or magnesium alloys, but is similar to annealed or normalized medium carbon steel. On an equal volume basis, the strength of pure zirconium approximates that of the copper-base alloys.

Satisfactory commercially pure zirconium sheet can be produced by forging in air at 700 C (1,290 F) and hot-rolling at 650 C (1,200 F). The tensile properties of such hot rolled sheet followed by cold working are shown in Fig. 6. Ninety percent of the work hardening results from the first 10 percent of cold rolling, but it appears that the limit of cold working is still not reached at 60 percent reduction. At 60 percent cold work no marked difference in properties exists between longitudinal or transverse specimens. It is believed such directional differences will be found only after about 90 percent reductions.

The impact strength of zirconium sheet rolled at 650 C varies from about 18 ft-lb at −200 C (Charpy V-notch) to 28 ft-lb at 600 C. Hot hardness values of zirconium plate (Fig. 7) are almost identical with those for titanium plate.

FABRICATION. Workability of zirconium is demonstrated by a wrench drop forged from an annealed zirconium rod, in the same dies used to produce similar alloy steel wrenches. Forging was accomplished at 1,200–1,290 F with no difficulty. Zirconium is also adaptable to stamping and drawing, for the production of small parts.

Rod and wire can also be produced from zirconium by hot and cold swaging and rolling. Hot working requires periodic cleanings and cold rolling necessitates intermediate anneals.

Zirconium can also be hot extruded. Annealed and hot-rolled zirconium sheet can be bent 180 deg on a 3T radius. Ten percent cold work increases the minimum bend radius to 8T, and 20 percent or more cold work raises it to 12–16 T. Thus cold work rapidly decreases the formability.

Zirconium can be spot welded without difficulty, and can also be Heliarc welded. Riveting, crimping and slotting also present no problems. No difficulty has been reported in machining ductile zirconium; it machines like soft, plain carbon steel.

CHEMICAL AND CORROSION PROPERTIES. Massive zirconium reacts rapidly with oxygen and nitrogen at elevated temperatures, resulting in hardening and embrittlement. Below about 1,300 F the metal can be processed in air for short periods of time without serious embrittlement, and at temperatures lower

Table IV—Properties of Zirconium Alloys*

Alloying Element	Limit of Addition Studied, Percent	Heat Resistance** at 1,200 F	70 F			1,200 F		
			Tensile Strength, psi	Yield Strength, psi	Elong. Percent	Tensile Strength, psi	Yield Strength, psi	Elong. Percent
Aluminum	5	C	120,500	96,300	7.5	54,500	24,600	26
Chromium	10	B	101,900	79,300	5.0	25,500	14,900	12
Molybdenum	10	C	145,000	136,000	7.0	43,180	14,750	44
Nickel	10	A	87,200	75,000	1.0	18,000	9,400	57
Tantalum	15	C	124,800	92,000	9.0	36,900	16,500	20
Titanium	90	C	162,300	139,100	3.0	24,700	17,300	77
None	..	B	.....	36,000	....	.....	9,100	..

* The strength properties are the highest strengths reported and do not necessarily correspond to the highest alloy content.

** A—weight gain less than 600 mdd (mg/sq decimeter/day)
B—weight gain 600–1500 mdd
C—alloy disintegrated in less than 24 hr

than 900 F only minor oxidation results. Hydrogen is readily absorbed above about 600 F, but can be removed by heating at about 1,500 F in vacuum.

Zirconium reacts readily with the halogens at temperatures between 400–750 F to form volatile compounds. It has been reported that chlorine water and solutions of halides capable of liberating chlorine embrittle zirconium badly.

The corrosion resistance of zirconium is good. Its resistance to corrosion by alkalis is outstanding, better than tantalum, titanium or 18–8 stainless steel. With respect to acid attack, the resistance is quite good except for hydrofluoric and very concentrated sulfuric and phosphoric. Its acid resistance is better than that of titanium and almost as good as that of tantalum.

In a 500 hr erosion-corrosion test at a temperature of about 400 F and a pressure differential of 300 psi, zirconium samples showed a much smaller weight change than samples of 18–8 stainless, carbon steel, and aluminum.

ALLOYS OF ZIRCONIUM. As with titanium, extensive research is underway for the development of zirconium alloys of superior strength and temperature resistant properties. Table IV shows properties of some of the preliminary alloys studied.

The physical properties listed are representative of annealed or slowly cooled alloys. Molybdenum and titanium have the greatest influence on increasing the room temperature strength of zirconium. Aluminum, tantalum, tungsten, chromium, columbium, nickel and silicon more than double the normal yield strength. Aluminum had the greatest effect in increasing the hot strength. Most of the alloys listed were readily forgeable. Alloys with the best heat resistance at 1,200 F have the lowest high temperature strength properties. At this stage of the investigation, none of the alloys studied appear to be satisfactory for high temperature applications, although up to about 1,000 F some may be useful.

FUTURE OF ZIRCONIUM. Based on development of the Bureau of Mines magnesium reduction process, zirconium may have an initial price of 5 dollars per lb for sponge.

The excellent resistance of zirconium to alkalis and certain acids may make it a likely replacement for tantalum for certain applications. A major field of structural applications apears to lie in the chemical industries.

MOLYBDENUM

The useful temperature limit of available high temperature materials is approximately 1,600 F, and it is not anticipated that this limit will be raised to any large degree by alloying modifications. A number of new materials are under investigation for operation above 1,800 F. Among the most promising are molybdenum and molybdenum base alloys, particularly for sheet applications.

One favorable and important attribute of molybdenum is its availability in the United States, which produces about 90 percent of the known molybdenum production of the world.

PHYSICAL PROPERTIES. Molybdenum is now commercially available in the form of wire, rods, bars, sheets and other shapes. Production of larger size ingots is increasing the size of sheet material available up to the limitations of the rolling and fabricating equipment.

Above about 1,700 F, molybdenum exhibits high temperature strength properties superior to many currently used high temperature alloys, as shown by Fig. 8. Table V lists some favorable physical properties of molybdenum.

Table V—Average Physical Properties of Molybdenum

Melting Point	2,530 C (4,750 F
Modulus of Elasticity	42 × 10⁶ ps
Specific Gravity	10.3
Specific Heat	0.65 cal/gm/C (20 to 100 C
Coefficient of Thermal Expansion	5.45 × 10⁻⁶ per C
Thermal Conductivity	0.345 cal/sec/cm/C
Electrical Resistivity	5.70 microhm-cm (at 20 C
Crystal Structure	Body Centered Cubic

Fig. 6—Effect of work hardening on the mechanical properties of zirconium sheet, hot rolled at 650 C, and cold worked.

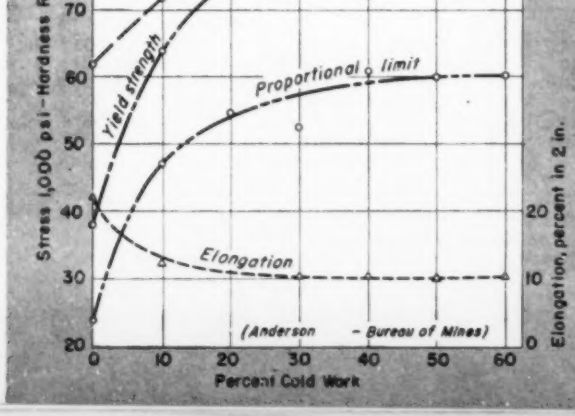
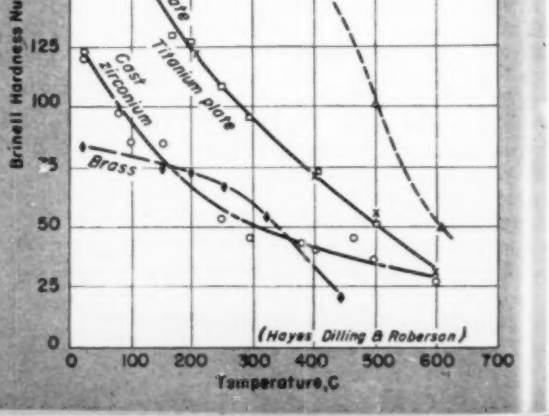


Fig. 7—Effect of temperature on the hardness of several metals. Hot hardness of zirconium and titanium are identical.



Strength properties are a function of fabrication, directionality and strain rate. The effects of annealing temperature on the strength properties of an arc cast hot-rolled bar are shown in Fig. 9. Within the temperature range of 1,200-1,900 F, stress relief occurs, and above 1,900 F recrystallization takes place.

Under many conditions molybdenum behaves in a brittle manner. Molybdenum is quite "strain rate" and "notch" sensitive, and when subjected to complex stresses or impact loading will exhibit poor toughness characteristics. Ductility of molybdenum is believed to be related to a fibrous, elongated-grain type of microstructure. When the microstructure consists of equiaxed grains, the metal exhibits poor room temperature impact properties and fails in a brittle manner. However, above a certain temperature, depending on the stress system involved, molybdenum becomes extremely ductile. This transition from brittle to ductile failure is often very sharp, occurring in a 5 deg F temperature range. It is believed that the responsible factor is the presence of impurities at the grain boundaries—carbides, nitrides or oxides.

The high temperature strength properties of molybdenum and its alloys are currently exciting the most interest. Above about 1,650 F (at which temperature the strength characteristics of the so-called "super alloys" deteriorate rapidly) pure molybdenum exhibits useful strength properties, far exceeding those of practically all commercial metals or alloys. Table VI lists some properties of arc cast molybdenum, in several conditions of heat treatment, at temperatures as high as 1,950 F. Above about 1,000 C (1,832 F) the creep strength of molybdenum is superior to available iron, nickel and cobalt base high temperature alloys.

The Vickers hardness-temperature curve for arc cast molybdenum shows a flat portion (at about 75 VPN) from 400 to 1,600 F: Dynamic hardness tests reveal that there is relatively little decrease in hardness values within the temperature range of 1,000 to 3,000 F. The slow rate of decrease of strength properties at these elevated temperatures as well as adequate strength magnitude offer promise for the use of molybdenum in numerous high temperature applications, including turbine blades, combustion chambers, guide vanes and other components of gas turbines, rockets and guided missiles.

Table VI—Mechanical Properties of Pure Molybdenum at Elevated Temperatures

Testing Temp, F	Condition	Tensile Strength, psi	Yield Str., psi 0.2% offset	Proportional Limit psi	Percent Elong. in 2 in.	Percent Red. of Area
Room Temp.	As Rolled	95,140			3	2
	Stress Relieved (1850 F)	91,000	84,850		10	9
	Recrystallized (2250 F)	67,600	63,500		46	56
1600	As Rolled	61,400	50,100	26,000	18	72
	Stress Relieved	50,600	44,500	21,500	22	81
	Recrystallized	34,400	11,600	3,500	46	84
1700	As Rolled	56,200	49,400	36,500	19	77
	Stress Relieved	46,500	36,200	22,500	16	72
	Recrystallized	32,800	11,000		44	76
1800	As Rolled	49,900	40,500	23,000	19	81
	Stress Relieved	40,500	35,600	22,500	32	81
	Recrystallized	29,000	10,500	5,700	49	75
1900	As Rolled	38,700	30,000	16,500		81
	Recrystallized	24,800	8,200	4,500	40	45
1950	Stress Relieved	31,400	22,800	16,500	36	84
	Recrystallized	21,500	8,550	4,100	35	52
1950	Hot Rolled	38,000	31,600	24,000	29	83

Fig. 8—Representative high temperature tensile properties of heat resistant metals show favorable properties of molybdenum.

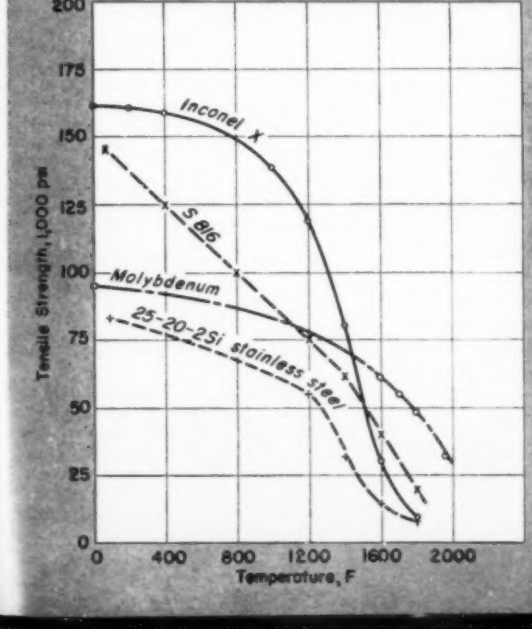
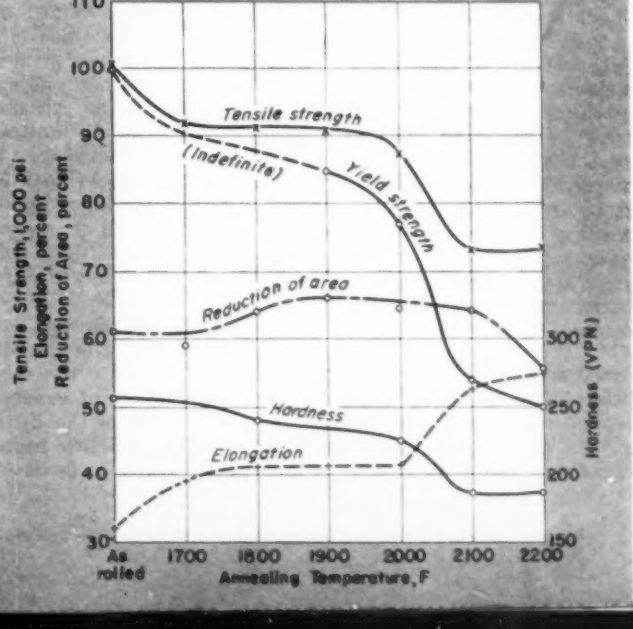


Fig. 9—Effect of annealing on properties of arc-cast hot rolled molybdenum bar (½ in. dia). Stress relief at 1200-1900 F.



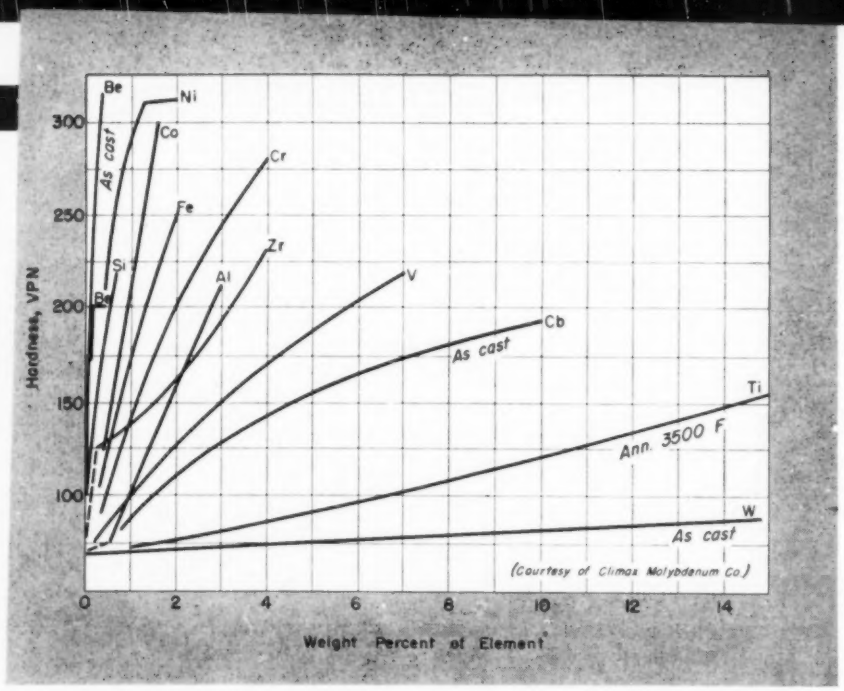


Fig. 10—Hardness of molybdenum-base alloys at 1,400 to 1,600 F. All materials were cast and annealed at 2,400 to 2,450 F. except as noted.

FABRICATION AND PROCESSING. Molybdenum can be formed into all shapes normally possible by powder metallurgy methods. The metal can be forged, rolled, extruded and formed into a variety of shapes, including forged octagonal, square and round bars, forged sheet bar, hot rolled and cold rolled sheet and rolled rounds. It can also be spun or formed by deep drawing.

Because of the high transition temperature of molybdenum it is often preferable to conduct such operations as shearing, bending, crimping, drawing, upsetting and spinning at slightly elevated temperatures (about 200 C) to minimize the possibility of brittle failure, particularly for heavier stock. Thin sheet can be drawn and formed cold. When applied stresses are complex, the rate of deformation should not be high.

Molybdenum can be successfully spot welded and arc-welded but the weldment is brittle at room temperature. Ductility of the weldment increases at elevated temperatures, allowing it to be hot worked. Production of ductile molybdenum welds by ordinary welding procedures will probably have to await solution of the more general problem of improving room temperature ductility in molybdenum.

CORROSION AND OXIDATION. Molybdenum does not have general corrosion resistance as good as zirconium or tantalum but it has outstanding resistance to cold or hot hydrofluoric acid. It also resists attack by cold aqua regia, dilute sulfuric and concentrated hydrochloric acids. Rapid reaction occurs with hot concentrated sulfuric, dilute nitric and hot dilute, hydrochloric acids.

From a high temperature structural material viewpoint, the most important chemical characteristic of molybdenum is its extremely poor oxidation resistance above 1,400 F. This is one of the most serious limitations that must be overcome for the application of molybdenum as a heat-resistant material.

Coatings of aluminum and nickel have provided some degree of protection, but the most promising protection has been displayed by coatings of molybdenum disilicide. Life tests of over 5,000 hr at 1,800 F and over 1,400 hr at 3,100 F have been obtained with coatings 2 to 3 mils thick. The coatings have also shown good service under load, and when subject to thermal cycling. The coating melts at about 3,500 F, limiting the useful temperature range. Methods still need to be developed for deposition in thicker layers and in a more feasible and economical manner. Vapor deposition techniques are currently being used. One of the disadvantages of all these coatings is that either the temperature of deposition or of the diffusion treatment is above the recrystallization temperature of molybdenum, which then renders the metal more susceptible to brittle failure. Methods still remain to be developed for the "low-temperature" application of protective coatings.

Some ceramic coatings developed by the Bureau of Standards showed no deterioration when exposed in air at 1,650 F for 70 hr. However, firing temperatures of ceramic coatings are also above the recrystallization temperature of molybdenum.

ALLOYS OF MOLYBDENUM. The potent effects of many of the elements in increasing the hot hardness of molybdenum are shown in Fig. 10. This hardness increase complicates the problem of fabrication of cast ingots. The hardness of arc cast molybdenum at 1,600 F is 70 VPN, and only those alloys which do not increase the hardness at 1,600 F to more than 90 VPN are forgeable. However, the alloys might be hot worked to a 1,600 F hardness as high as 180 VPN if suitable extrusion dies could be developed.

Until hot working techniques can be developed to utilize the full strengthening potentialities of alloying elements, the selection of an alloy for applications requiring hardness and strength at elevated temperature will necessitate compromises between the desired hardness and the ability to hot work the alloy. For certain shapes and applications powder metallurgy techniques may prove to be most feasible. Possibilities also exist that ternary or more complex alloy systems will have satisfactory oxidation characteristics.

References

Anderson, C. T. et al. "A Preliminary Survey of Zirconium Alloys", Bureau of Mines Report of Investigations No. 4658.

Barrett, P. F., "Compressive Properties of Titanium Sheet at Elevated Temperatures", NACA Tech. Note 2038.

Bounds, A. M., "And Now Titanium Tubing", *Iron Age*, April 6, 1950.

Ham, J. L., "Arc-Cast Molybdenum Base Alloys", Climax Molybdenum Co. Report, April, 1950.

Hayes, E. T., Dilling, E. D., and Robertson, A. H., "Fabrication and Mechanical Properties of Ductile Zirconium", *Trans.* ASM, *42*, 619.

James, J. H., "Corrosion Resistance of Titanium and Titanium Alloys", U.S. Naval Aeronautical Materials Lab. Report.

Parke, R. M., "Molybdenum as a Heat Resistant Metal", Battelle Memorial Institute Report G 1332-1.

Pitler, R. K. and Jaffe, L. D., "Toughness of Titanium", *Metal Progress*, June 1950.

Williams, W. Lee, "The Corrosion and Mechanical Properties of Titanium and Zirconium at Normal Temperatures", U. S. Naval Eng. Experiment Station Report C-3395, C-3501 B.

COLOR SERIES ON

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A functionally perfect product is not enough in a competitive market. The product must look like it will efficiently perform the job, and it must be attractive in appearance. Finish of course, is an integral part of appearance. It may well be responsible for the commercial success or failure of a product. Product Engineering presents the first of a series of articles, illustrated in full color, to evaluate the field of surface coatings for appearance and protection.

Which Coating for Gray Iron?

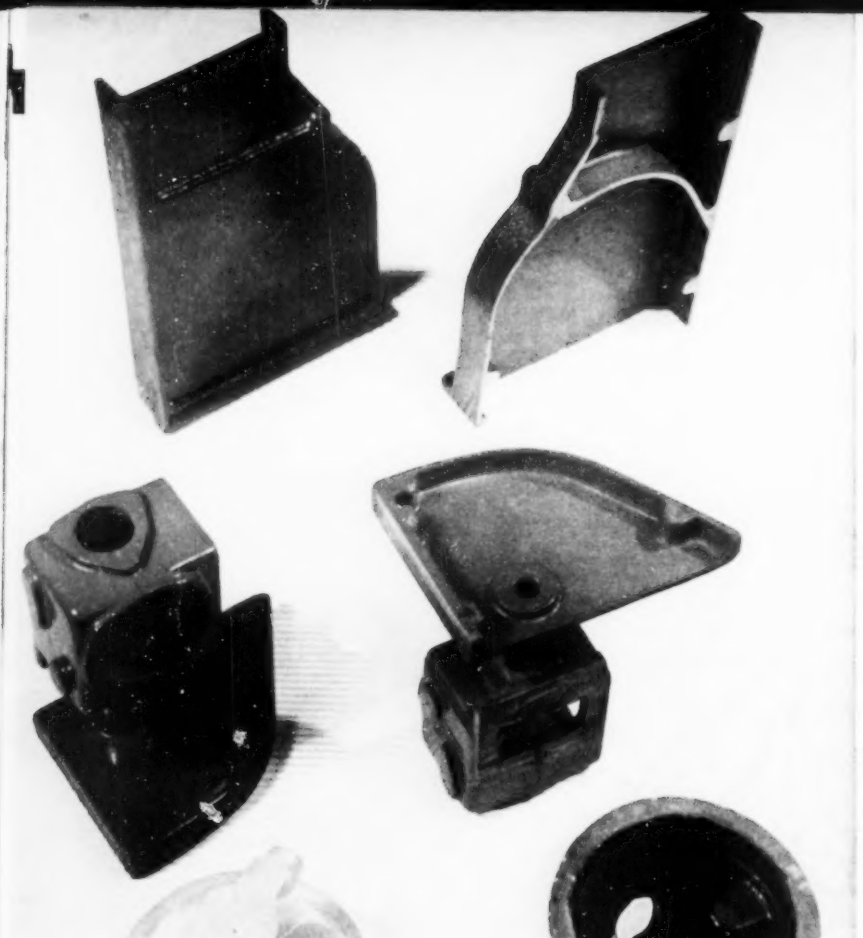
CHARLES O. BURGESS
Technical Director, Gray Iron Founders' Society

APPLICATIONS for gray iron can be greatly expanded if surfaces of castings can meet a wide variety of finish specifications. Since gray iron is in many respects one of the most economical of base metals, careful consideration of applicable finishes is worthwhile. By utilizing the strength and economy of cast iron, and the surface characteristics of a specific finish, considerable savings can be effected, when compared to the use of a more expensive base material.

In general, most surface coatings can be divided into two categories: Non-metallic and metallic. This article is concerned with the former—organic and "chemical" finishes— and the latter will be covered in a subsequent issue of Product Engineering.

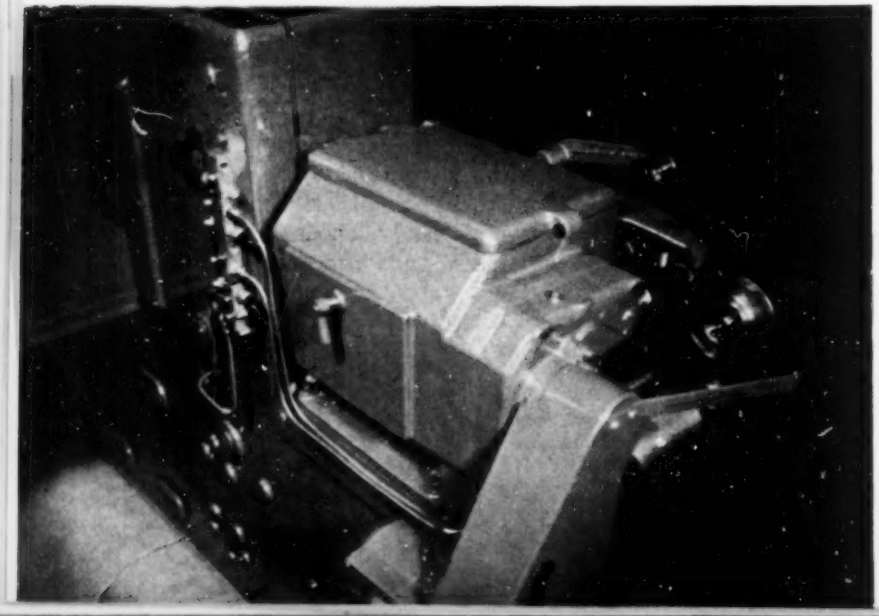
Organic Finishes Are Versatile

Organic paints, lacquers and enamels are effective and convenient in improving appearance and in protecting the casting surface against rusting and special corrosive conditions. On gray iron or other ferrous materials, such finishes form a continuous, inert film, thus preventing contact with corrosive atmospheres, liquids or gases. The almost limitless variety in color and texture which



Cigarette-making machine castings: Inside surfaces finished with organic sealer, and outside paint baked over sealer. Top, drive printer cover; center, drive gear housing; bottom, dome for cutoff knife adjuster. Yellow dome shows inorganic chromate primer. American Machine and Foundry Company

Cast housing for thrasher on tobacco leaf stemming machine is finished with synthetic resin sealer and paint. Synthetic resin finishes are becoming increasingly popular for gray iron castings. American Machine and Foundry Company



can be obtained make organic finishes the most attractive coatings for decorative purposes. They provide easily cleaned surfaces, and their high light reflection increases safety.

Since the field of organic finishing is complex and is rapidly expanding, it is difficult to evaluate the many materials on the market, or to make a final choice of a finish for a specific application. However, at the risk of oversimplification, organic finishes used to coat gray iron can be divided into three main types, which are different mainly in kind of base material or "vehicle":

1. *Oleoresinous or varnish base finishes* are composed of drying oils (linseed, tung, soya), natural and or synthetic resins, and pigments. Petroleum thinners, metallic driers and other special agents are usually added. This finish is the slowest drying even if baked, and the least expensive of those used on gray iron. High solids content permits deposition of heavy films, but color retention under heat, chemical resistance and film quality are only fair. Although oleoresinous finishes are still in use, there is a tendency to convert to the more rapidly drying lacquers or synthetic resin base finishes.

2. *Lacquers* consist of nitrocellulose resins, plasticizers and pigment dissolved in volatile organic solvents of the ester and alcohol types. The finish film forms when these solvents evaporate. Lacquers air dry more quickly than other finishes and can be force dried at temperatures up to 180 F. They are applied widely where speed of finishing is of prime importance. Recent improvements in toughness, durability and chemical resistance of lacquer films have added to their commercial usefulness. Because the films are thin, they are used over a primer and/or filler.

3. *Synthetic resin base finishes* consist of one or more synthetic resins, combined with pigments and drying oils for the non-volatile portion, and volatile petroleum or coal tar solvents. Many synthetic resin types (styrene, phenolic, alkyd, amine and vinyl) have been developed for specific applications. Synthetic resin finishes are intermediate in air drying rate between oleoresinous and lacquer finishes. They can be baked at comparatively high temperatures (usually 200-350 F), and consequently lend themselves to fast production schedules, often competing with lacquer in speed of drying. They are tougher

and more resistant to chemicals than the two other types. Whether air dried or baked, they have unusually good film life, quality, and appearance.

Combinations of two of these types may sometimes be valuable for a specific purpse. For example, the addition of synthetic resins to lacquer results in a finish combining many of the desirable features of both.

Omitted in these three main types is common oil-type paint, consisting simply of a pigment, drying oil and suitable solvents. This paint type is gradually being superceded by the three types described and is not widely used on gray iron.

The division of finishes into three types was based on the composition of the vehicle which carries the pigment. However, within a given class or type the pigment-binder ratio—the amount of pigment in relation to the amount of non-volatile solids in the vehicle—can be altered to meet a specific application. For example, with a given paint a low pigment-binder ratio will be selected if a high gloss typical of an enamel is desired, whereas a high pigment-binder ratio is chosen if filling qualities are more important than a brilliant gloss.

SPECIAL TEXTURE FINISHES. Attractive finish coats for gray iron which eliminate expensive filling, smoothing and sealing operations, have recently been developed. These one- or two-coat finishes give adequate protection for most industrial applications and greatly improve surface appearance at moderate cost. These coats include combinations of various colored or metallic enamels, resulting in attractive three-dimensional characteristics. These so-called wrinkle, hammered, or spatter finishes blend well with and de-emphasize small irregularities of as-cast surfaces.

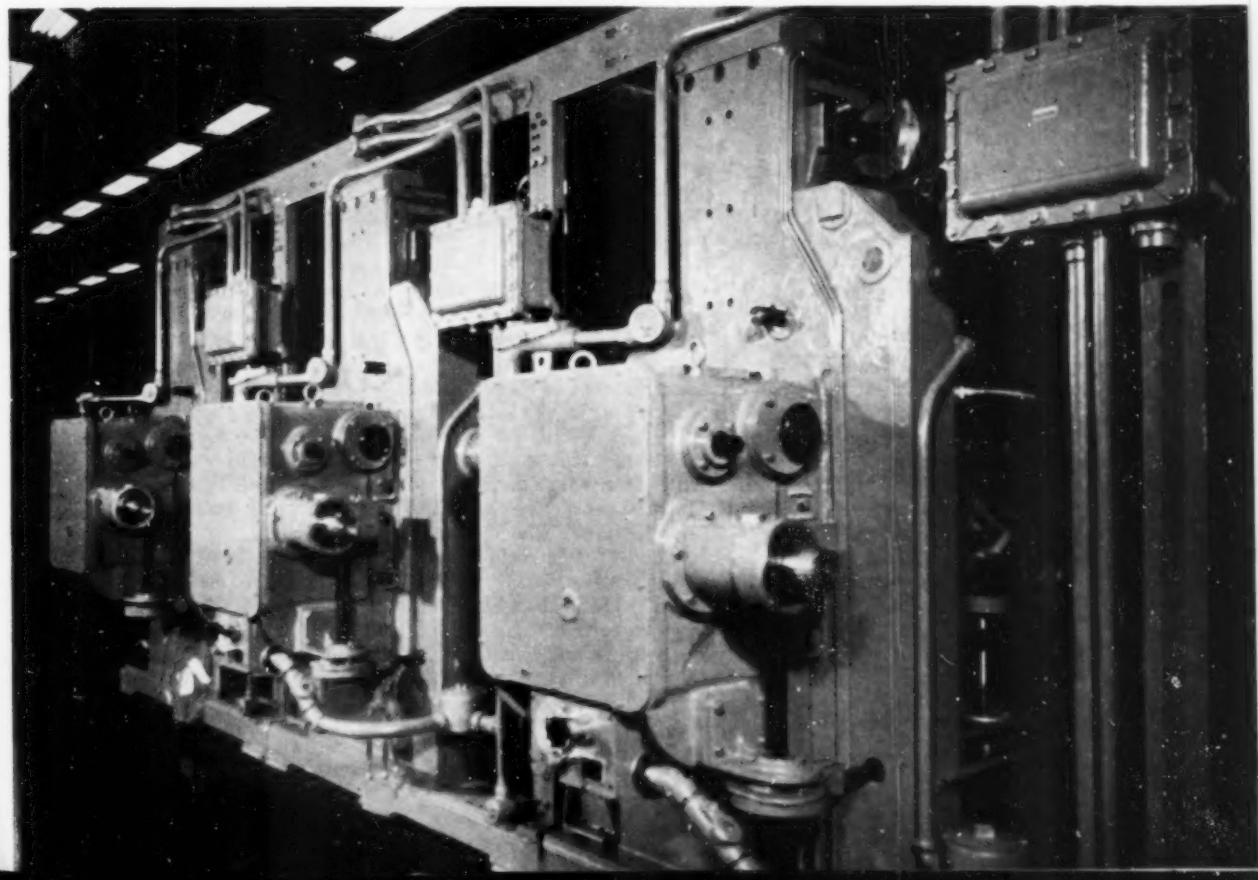
Wrinkle finishes are sprayed directly on castings. Their characteristic appearance results from contraction of the upper layers of the sprayed paint into ridges during drying. The wrinkle finishes, normally one coat applications which must be baked, can be varied in texture from very fine (suede) to very coarse (pine tree) patterns. They are effective in all colors but the lightest.

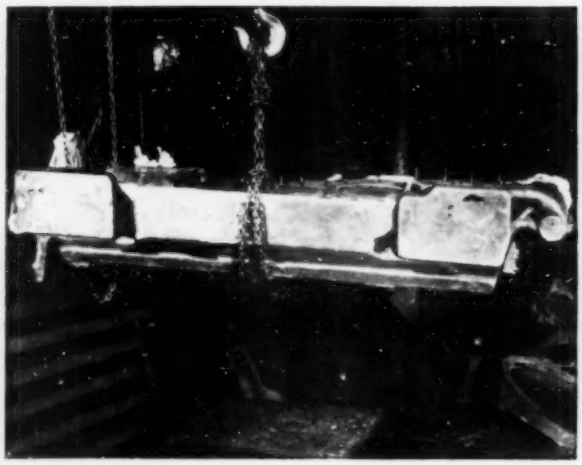
The "hammered" finish effect is obtained from metallic powders, usually aluminum, suspended in the paint. The "pattern illusion" greatly enhances appearance of castings. Hammered finishes, like wrinkle finishes, can be applied in one spraying, have good adhesion and film qualities, but possess much less depth of texture. They can be either air dried or baked.

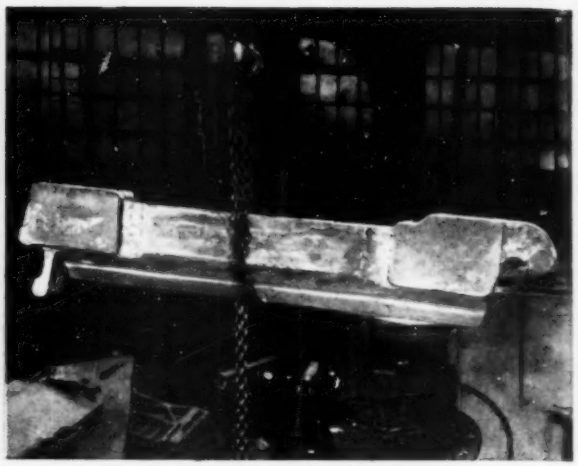
Spatter finishes consist of a base coat over which a layer of heavily textured spatter has been applied. These two coats may be of the same or of contrasting colors. This finish has the advantage of being thicker, tougher, and, therefore, more protective than either the one-coat wrinkle or hammered finish. Baking is required for best results and film quality, but air drying spatters have been developed.

CORROSION INHIBITING PRIMERS. Protection of the freshly tumbled, sand-blasted or shot-blasted casting for shipping or storage is very important. The simplest corrosion protection for short periods is application of a corrosive-inhibitive oil or grease. However, for extended yard storage a more durable coat is needed, and various inexpensive paints have been developed. Oleoresinous finishes are most frequently employed. Under moderate corrosive conditions the widely used red oxide primers will provide good protection at comparatively low cost, but the pigment

Cast iron structural parts of printing machine, including gear and drive housings and switch boxes are finished with synthetic resin (alkyd type) sealers and paints, which resist the action of printing inks. Ford Instrument Company







does not in itself inhibit corrosion. For drastic corrosive conditions or longer periods of exposure, the more expensive red lead and zinc chromate primers are preferred. This increased cost can be partly charged against subsequent finishing operations.

When a complete finishing system has been decided on, the best procedure is to select a primer which will fit into that particular system. Thus if a synthetic resin air-drying system is to be used by the manufacturer of the finished product, a good modified alkyd resin base primer might be used. The higher cost of such a primer is offset by eliminating a rust removing, degreasing or stripping step.

COMPLETE FINISHING SYSTEM. For a still more protective and decorative coating than those previously described, a standard finishing system has been developed for gray iron machine parts, but is applicable to any casting. Oleoresinous, lacquer or synthetic resin base finishes or combinations of these can be used, depending on the requirements of cost, speed, toughness and corrosion protection.

1. The casting is first sand or grit-blasted and deburred.

2. If oil or grease are present, standard alkaline cleaners can be used. Oil should be removed if lacquer finishes are to be applied. There is on the market a useful cleaning preparation containing solvents and phosphoric acid, which can be wiped on a large casting to remove rust and produce a good surface for organic finishes.

3. Immediately after cleaning a primer should be applied. This may contain corrosion inhibiting pigments such as red lead or zinc chromate, especially if the casting is to be stored previous to shipment or further finishing. Interior machine or engine parts that will not be further finished, such as gearcases, should be coated with a special primer known as a "crankcase sealer" which prevents adhering sand or other abrasive material from getting into the oil, and protects against corrosive action of the lubricants.

4. Filler or glazing putty is next knifed or squeezed onto the surface to smooth out any surface roughness. On small castings this filler can be applied by spraying.

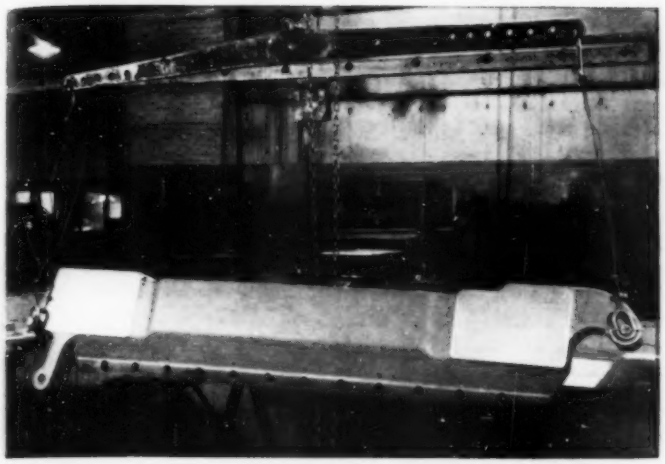
5. The filler is then sealed with a coat of "sealer" or surfacer to give maximum smoothness and minimum absorption of the finishing coats. This is a synthetic lacquer with a very low pigment-binder ratio.

6. After machining and assembly, another coat of sealer is sometimes used to repair any marring of the surface, and the desired type of final surface coat is then applied by dipping, spraying or brushing.

SPECIAL SYNTHETIC RESINS. In recent years many synthetic base paints have been developed for specific applications. The oldest of these are the phenolic resins, characterized by their corrosion resistance, abrasion resistance, electrical insulating properties, and resistance to moisture and weathering. They are applied in the food industry, beer and wine industry, in chemical laboratories, and in high-temperature electrical equipment. The amine-formaldehyde resins, usually modified with alkyds, are used in kitchen, bathroom and hospital equipment, where their excellent color retention and resistance properties are especially desirable. Melamine-formaldehyde resins are color retentive even at very high temperature and find application in stove parts and electrical accessories. Of potential importance when price is a secondary consideration are the silicone resins which have unusual hardness, toughness and resistance to heat, chemicals (including dilute acids) and weathering.

Two other types of synthetics, vinyl resins and chlorinated rubber base paints, have recently assumed great importance. The vinyls are resistant to abrasion, caustic, moisture and corrosive conditions, and are completely lacking in taste, odor or toxicity. They are thus particularly adapted to use in the food industry and in chemical manufacture. Chlorinated rubber base paints, because of their superior chemical resistance, in addition to hardness and rapid drying, are being widely applied in washing machines, commercial laundry and bottling machines, acid plants and oil refineries. These synthetics can be either air dried or baked.

ASPHALT OR PITCH-BASE ENAMELS, JAPANS. Asphalt or pitch-base enamels are applied where increased resistance is desired to alkalis, sewer effluents, acids, and continued exposure to tap waters. They are applied either hot or cold. In the hot process, castings, large



Evolution of a finished knife bar casting: Left, as-cast condition, just out of the mold. Center, casting has ben sandblasted, snagged, and ground, to remove "flash". If oil or grease are present, standard alkiline cleaners can be used at this point. It is now ready for coating operations. Right, knife bar casting has been primed, filled, sanded and sealed, and is ready for assembly. After machining and assembly, another coat of sealer can be applied to repair any marring of the surface, followed by dip, spray or brush application of a final coat if desired. Harris-Seybold Company

pipe or pipe fittings, are immersed in the liquid bath at approximately 300 F. The castings themselves are usually at an elevated temperature. In cold applications, the enamels are largely limited to the asphaltum type, because of its superior solubility in the petroleum spirits used as thinners. The quick drying character of these enamels (10 min at 70 F) and the ease of surface preparation have made them popular. These can be sprayed, dipped or brushed on the casting.

Japans vary from the low cost type containing Gilsonite or asphalt dissolved in petroleum thinners to more expensive varieties compounded to resemble lacquers with vegetable oils and plasticizers. Because of very slow drying qualities, they are almost always baked at elevated temperatures (usually over 400 F for approximately 4 hr). They are naturally brownish-black to black in color ("black japans") and lampblack is sometimes added to increase opacity. A hard, glossy, durable and abrasion-resistant film with good resistance to moderate heat and acids can be developed. This, coupled with economy, has led to their use on heaters and similar equipment. However, the cheaper grades of japan may exhibit film brittleness and lower corrosion resistance than higher cost paints.

ALUMINUM PAINT. Aluminum metal pigment in an oleoresinous or synthetic resin base paint produces a finish resembling a layer of solid aluminum. This metallic pigment "leafs"; that is, the flakes migrate to the surface of the paint film during drying. The finish is resistant to corrosive atmospheres and heat, and is particularly useful in giving interior machine parts maximum visibility.

Vitreous or Porcelain Enamels

Porcelain enamels are composed of inorganic material, ceramic in nature, and must be fused onto the casting at high temperatures. Vitreous enamel has almost complete chemical and corrosion resistance. Acid resistant enamels which can resist all common acids except hydrofluoric are available. The resistance to alkalis, though not quite as great, is sufficient for many applications. The extreme hardness and scratch-resistance of vitreous enamel coatings permit the use of enameled castings where abrasion would quickly destroy an organic coating. Vitreous enamel finishes range from very high gloss to matte and can be produced in a wide variety of colors. Because of their refractory base, they can be used at high temperatures and withstand violent changes in temperature.

Vitreous enamels can be applied by either the wet or dry process. In the wet process the basic enamel (or frit) is suspended in a water solution of certain electrolytes which is then dipped or sprayed onto the casting. This process can be used on any size castings, but is usually applied to medium weight and small castings. Although some one-coat enameling is done, it is more usual to apply three coats, which are generally thinner and more opaque than in the dry process. The process is more flexible than the dry process, particularly where deep pockets and recesses are encountered. Firing temperatures of 1,450 F are rarely exceeded.

In the dry process, dry, finely divided enamel is dusted on a previously dipped or sprayed ground coat of a casting heated to around 1,600 F and the casting is then returned to the firing furnace. The dry process is generally preferred for large castings. Firing temperatures are higher (up to 1,700 F) to assure flowing of the dry enamels. Enamel thickness approximates 0.04 in. and is materially greater than in the wet process. The final dry enameled surface is softer and has a higher gloss than the wet process enamel.

For best results two or more coats of enamel are necessary. The main functions of the first or ground coat are to prevent chemical reaction between the casting and later cover coats, to prevent oxidation of the gray iron at high temperatures, and to seal up or smooth over surface irregularities. The cover or top coat determines the characteristics of the enameled finish: Color desired, gloss or matte finish, and degree of resistance required to acids, alkalis, weathering, hot water, soil corrosion, scratching and abrasion, thermal shock or high temperature.

White enamels are classified according to the oxide which is used as the opacifier—antimony, zirconia, or antimony-zirconia formulations. The antimony enamels, the oldest of the three types, can be made highly acid resistant but do not easily produce a good finish and

have low scratch and abrasion resistance. Zirconia enamels, while having poorer resistance to acid, are highest of all in alkali resistance and higher than antimony enamels in resistance to thermal shock. Zirconia enamels also provide a better finish and, since they have greater opacity, or hiding power, can be applied in thinner coats. To some degree the advantages of both types can be obtained by formulation.

Recently titania opacified enamels have aroused interest because of their resistance qualities, ability to be applied in thin coats, high scratch resistance and thermal shock resistance. Their application to gray iron using the dry process may be somewhat delayed because their melting points are higher than conventional enamels. This limitation does not exist in the wet process; widespread interest is shown in developing titania enamels suited to gray iron castings.

Cast irons in a wide range of composition can be enameled. Good foundry practice and a surface free from pinholes is more important than analysis. It is advisable to keep the combined carbon fairly low (approximately 0.40 percent) and avoid alloys that affect carbide stabilization. Sound castings that can be sandblasted to a fairly smooth surface are required.

Design of castings intended for enameling is important. Care should be taken to avoid castings with uneven section thickness, as these will not heat up uniformly during firing and thus may cause blistering of the enamel. Corners both inside and out, should be rounded and the radii of fillets should be generous.

Decorative patterns can be applied over or made a part of the fused enamel. Possibilities of improving sales appeal through production of artistic effects are only beginning to be effectively exploited.

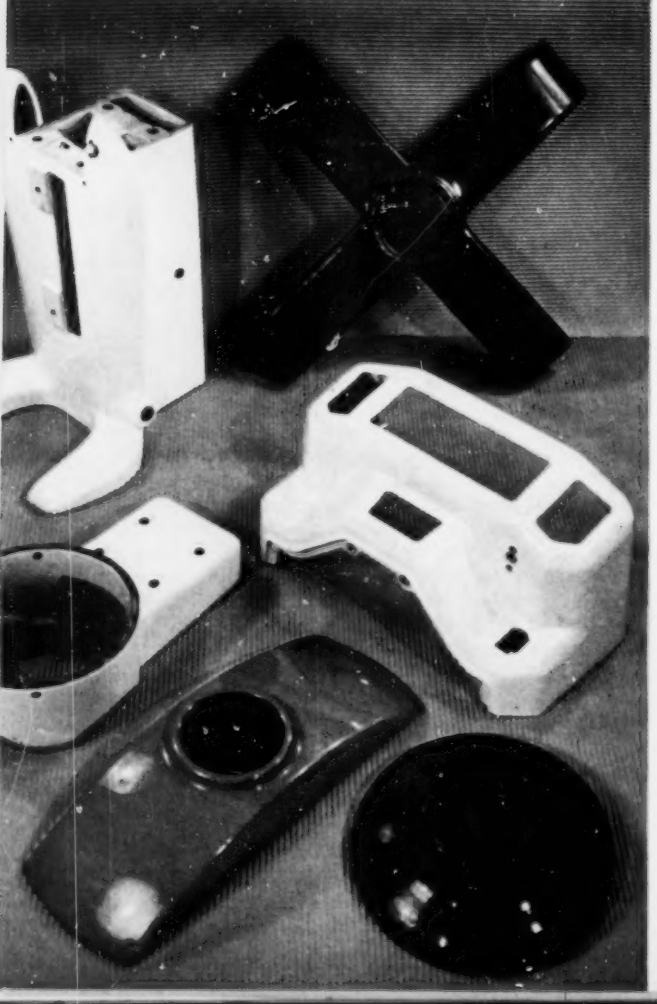
Vitreous enameled castings, although firmly entrenched in applications such as sanitary ware, have not received recognition commensurate with their high resistance to service hazards. The advantage of enameled castings lies in their design, which makes them much less subject to warpage and distortion than wrought, sheet or welded assemblies. The final enameled casting, because of its resistance to flexure and its high vibration absorption, is also much more resistant to flaking of enamel than thinner wrought steel parts.

Iron castings finished by vitreous enameling have found wide use in industry and in the home, where wear resistance and sanitation requirements are at a maximum. Many applications in the chemical industry have been found.

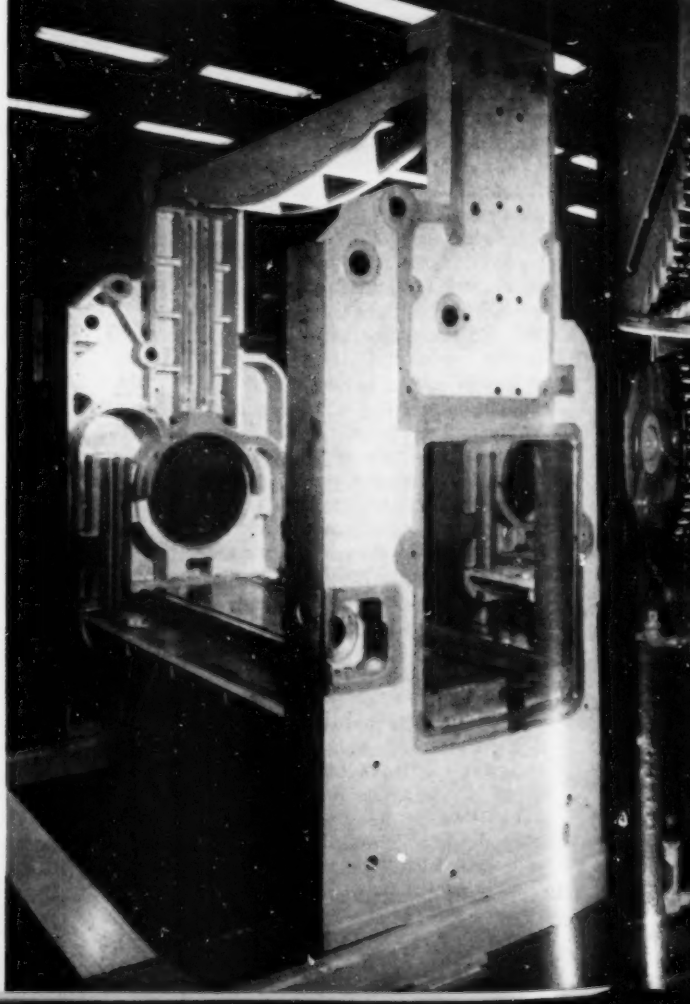
Chemical Conversion Coatings

Chemical coatings are formed by the conversion of the iron or alloying elements on the surface of a casting into a metal compound, us-

Color-finished gray iron castings include mixer base and top, two table bases, scale housing, and stool base—coated with porcelain enamel. Chicago Hardware Foundry Company



Printing machine frame casting, showing surfaces which are to be "hidden" after assembly left with coat of synthetic resin (alkyd) sealer. Ford Instrument Company

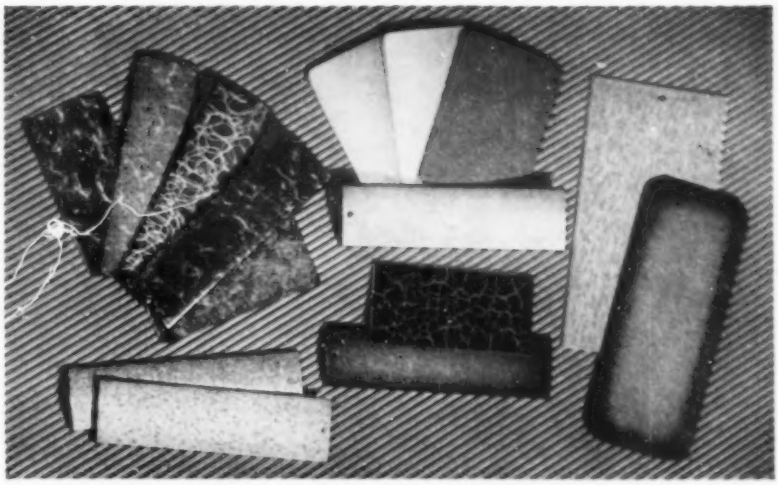


ally by immersion in a solution or exposure to a particular atmosphere. They are valuable for many special applications, furnishing such properties as attractive appearance, wear resistance, heat resistance and ability to bond organic coatings to the metallic surface. The coatings are usually thin and somewhat porous, and, therefore, do not provide any substantial corrosion protection unless a subsequent organic finish is applied.

OXIDE COATINGS. This process depends on transforming the surface of the casting to ferric oxide and inhibiting the formation of rust.

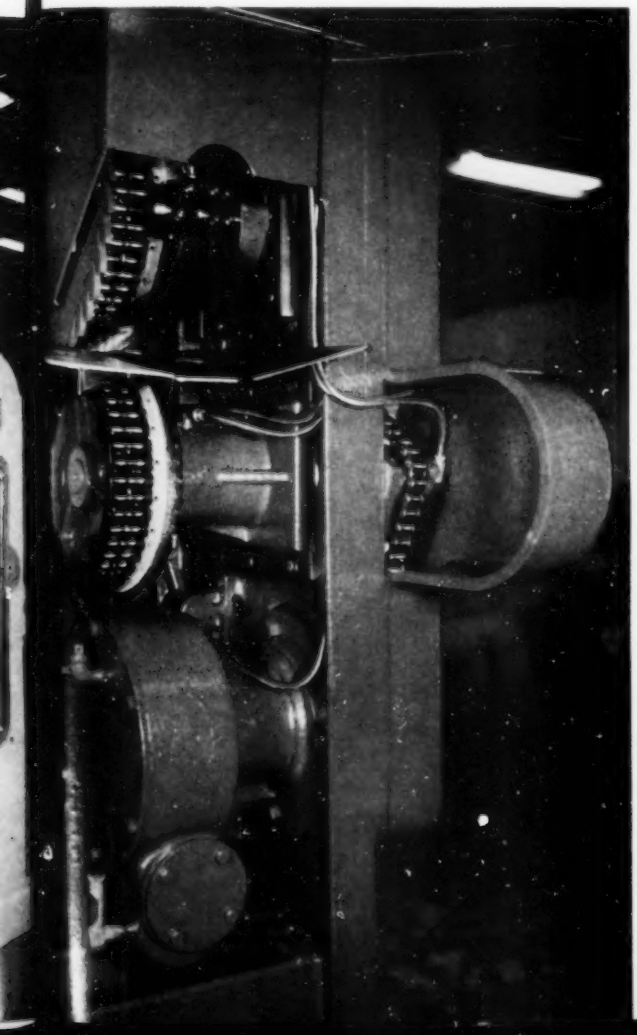
The older method of producing a black oxide coating is the so-called Bower-Barff process, which depends on the fact that above 900 F in the presence of steam a good, adherent black oxide coating will form on a gray iron casting. This is used where thick, tough and wear resistant oxide coatings are required.

If a thinner, decorative finish is desired, one of the commercial alkali-nitrate baths is employed. These operate more rapidly, require less skill in operation, and produce more uniform finishes if a large quantity of articles is being produced. The alkali-nitrate baths used on steel will not produce a good black finish on gray iron. There are, however, proprietary

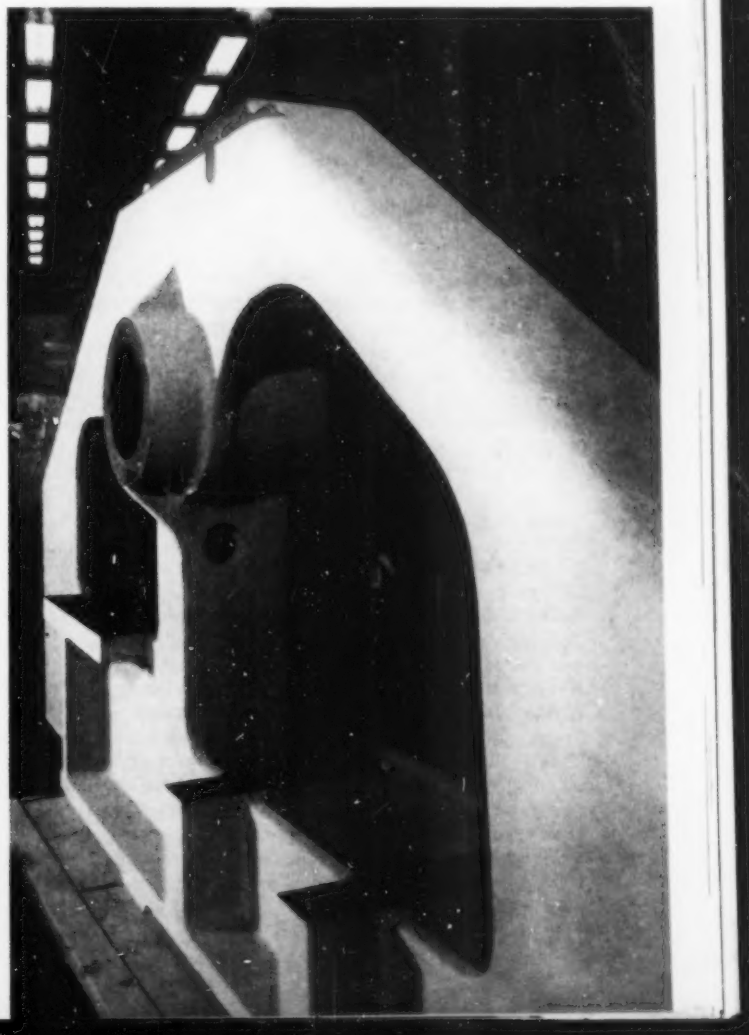


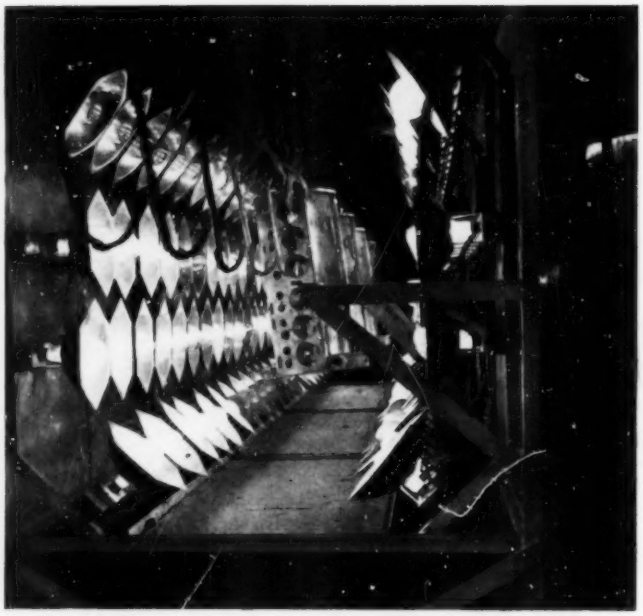
Special-effect organic finishes: Spatter, one-and two-coat hammer, veiled lacquer, wrinkle, and webbed lacquer. The Glidden Company and the du Pont Co.

Tobacco leaf stemming machine. Side frame and drive box castings have been coated with primer and/or sealer and a synthetic resin. American Machine and Foundry Company



Side frame of large printing press is a gray iron cast which has been treated with an organic sealer, and finished with a synthetic resin paint. Ford Instrument Company





Corrosion-inhibiting primer, on gray iron cylinder blocks, is dried in infra-red heating tunnel. Campbell, Wyant and Cannon

Parker Rust Proof Company

Typical racking setup for chemical immersion treatment of cast iron valve guides.

processes for the blackening of gray iron which yield excellent adherent black oxide coatings. These involve the use of special addition agents to the alkali-nitrate bath or the dipping of the casting in a special solution subsequent to treatment in the bath recommended for steel. The final coating is not a pure ferric oxide coating, but may contain oxides of manganese and mixed sulfides.

PHOSPHATE COATINGS. These consist essentially of a layer of iron phosphate crystals plus zinc or manganese phosphate crystals. Since they are chemically neutral, such coatings protect the surface from progressive corrosion by the atmosphere; the surface is an excellent base for paint, and they aid in preventing seizing of wearing parts during "break-in".

There are three main types of phosphate coatings: The first type, a light, highly absorbent coating deposited on the casting surface by dipping or spraying the casting with a zinc phosphate solution, is used as a base for paint. The phosphate layer prevents corrosion from spreading under the paint, if the protective film ruptures. One of the many applications of the process is in gray iron electric motor parts that are often exposed to corrosive atmospheres.

If painting is unnecessary or undesirable, such as in castings for indoor applications or in threaded parts, a thicker (0.0003-0.0005 in.) zinc- or manganese-iron phosphate layer is produced by treatment with acid zinc or manganese phosphate solutions. Iron castings submitted to this treatment find wide use in such applications as automotive parts, farm implements, tire molds, metal cases, and ornamental iron.

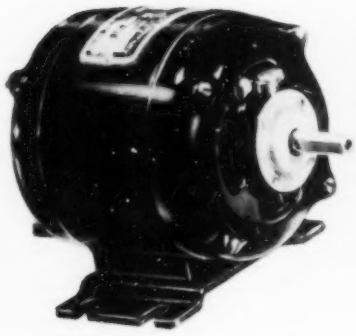
A third type of application utilizes a relatively thin coating (0.00004-0.00006 in.) of manganese iron phosphate, rendering the surface highly absorptive to oil or a suspension of colloidal graphite in oil, greatly increasing the lubricating qualities and permitting rapid "break-in" of moving parts without scuffing, seizing, or welding. Cylinder liners, pistons, piston rings, valve tappets, gears and crankshafts are typical castings that are commercially phosphatized.

Surfaces to be phosphatized should be machined or sandblasted, and freed from any oil and grease, usually by immersion in an alkaline cleaner. The phosphatizing solutions are proprietary, and consist of zinc or manganese phosphate, free phosphorous acid and accelerators. Phosphatizing operations must be conducted at elevated temperatures (180-210 F). Thin zinc phosphate coats for paint-bonding are usually sprayed on the casting while thicker coatings are produced by dipping the casting. For small parts rotating barrels are often used.

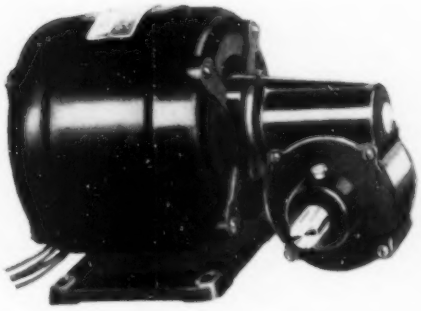
Cement Lining and Armor

Cement lining is one of the most effective and economical methods of protecting iron castings, such as pipe, against corrosion by fresh and salt waters. Casting surfaces form an excellent base for such a lining. Although the cement is originally somewhat porous, water seeping through the lining tends to form corrosion products which, in turn, appear to react with constituents of the cement effectively plugging the pores and preventing or inhibiting further corrosive attack. With brines or salt water, alumina type cements are recommended by some authorities. Some specifications include spraying, dipping or brushing a seal coat of water-proof bituminous paint over the cement lining. Such a seal coat will prolong the life of the lining and is particularly necessary in contact with waters corrosive to calcium carbonate, such as water of low alkalinity.

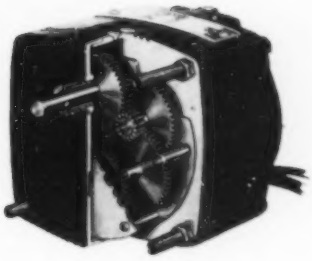
EDITOR'S NOTE: An article by Mr. Burgess, covering "Metallic Coatings for Cast Iron", will be presented in the December issue of PRODUCT ENGINEERING.



The Standard Fractional Horsepower Motor



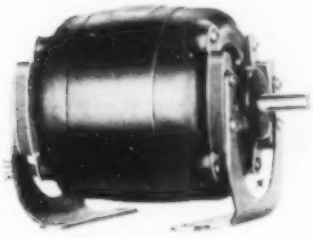
Motor With Worm Gear Speed Reduction



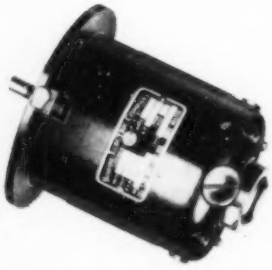
Motor With Integral Spur Gear Reduction

Special versus Standard

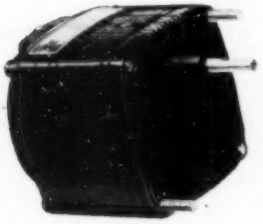
FRACTIONAL HORSEPOWER MOTORS



Resilient Mounting For Vibration Isolation



Motor For Flange Mounting



Assembly Bolts Extended For Mounting Purposes

Modified motors solve many design problems. But cost must be watched. Here are some typical "specials" and the factors that determine whether they should be chosen over "standards".

R. R. EVERETT
Bodine Electric Company

WHILE IT IS IMPOSSIBLE to give the exact formula for a good designer, he must certainly be part engineer and part economist. Day after day, decisions must be made that affect not only the performance of the final product, but its cost as well. A typical problem is the specification of fractional horsepower motors. Whether to specify a catalog motor or a "special" is a question that is best solved only with a thorough knowledge of characteristics, application and cost.

Many factors are involved in choosing a motor for a small machine or instrument. The power supply is one. Usually, the designer cannot select voltage, or frequency, since they are already fixed for a particular product by electrical codes, general acceptance or by the power available.

Once the power supply is known, the characteristics of the driven load are determined. A motor with performance characteristics coinciding as nearly as possible to the load requirements is chosen as a starting point. The accompanying chart, Table 1, is helpful in the selection of the correct type of motor. Other points, however, have to be given consideration. For example, the range of ambient temperatures in which the motor is to operate as well as the type of enclosure should be taken into account. The standard motor is designed for 40 C maximum ambient temperature. Normally, the maximum temperature of the motor windings is 105 C. A ventilated motor may carry the load placed on it in an open atmosphere without exceeding the permissible temperature rise, but if placed in an enclosure of great

Table I–Fractional Horsepower Motor Selection Chart

	Split-phase	Shunt or compound	Series	Polyphase	Synchronous	Synchronous polyphase	Synchronous capacitor	Shaded pole	Series governor	Capacitor	Capacitor start
CURRENT SUPPLY											
A-c	●			●	●	●	●	●		●	●
D-c		●									
A-c or d-c			●						●		
DUTY											
Continuous	●	●		●	●	●	●	●		●	●
Intermittent			●						●		
ROTATION											
Unidirectional			●					●	●		
Reversible at rest only	●				●		●				●
Rev. at rest or rotating		●		●		●				●	
SPEED											
Constant fixed	●			●	●	●	●	●		●	●
Constant adjust.		●							●		
Variable			●								
STARTING TORQUE											
Low							●	●		●	
Normal	●	●	*●		●						
High				●		●			●		●
STARTING CURRENT											
Low							●	●		●	
Normal	●	●	●	●	●	●			●		†●

* Starting torque high for series motors with normal speed ratings of 7500 rpm or more
† Starting current appreciably lower than for split-phase motors

restriction the final temperature becomes too high. The solution is either to limit the temperature rise of the motor by forced cooling or alter the enclosure in which it is placed. The ambient and operating temperatures also influence the selection of the most suitable lubricant for long motor bearing life.

For fractional horsepower motors as well as those of larger size, duty cycle is of prime importance. Severe duty cycles, such as frequent acceleration, varying loads and plugging, may have a heating effect on the motor that is greater than that calculated for normal starting and running requirements. On the other hand, when the duty cycle is light an intermittent duty motor may do the job. While most motors, with the exception of series-wound units, are rated for continuous duty service, there may be instances where valuable space can be saved by using a smaller motor rated intermittently.

The condition of the surrounding atmosphere is an element to be observed. High humidity or corrosive atmosphere call for special insulation and special treatment of metal parts for satisfactory motor life. The position in which the motor is mounted is part of the design analysis. This may be one of the determining factors in specifying ball bearings or sleeve bearings. Thrust bearings may be necessary in connection with sleeve bearing units. The mounting position will also determine arrangements for proper lubrication of some motors.

Fractional horsepower motors are available in a large assortment of standard specifications for machines rotating at speeds lower than the motor shaft speeds. The motor and speed reducer are combined in an integral unit conserving valuable space. Both worm and spur gear reductions are available. These are standard units with some small motor manufacturers.

Worm gear reductions are especially adapted to slow speed drives because high ratios can be built into a small enclosure. Spur gear reducers are usually more efficient than worm gear reducers but often require more space and are generally not as quiet. Care must be taken in applying worm gear drives or spur gear drives of high ratio to see that loads of high inertia are not coupled directly to the drive shaft. The momentum of the load during starting or stopping may transmit severe shock to the gears, possibly causing damage or breakage. On loads of this kind or on loads that may lock or involve shock from other causes, a safety clutch or shear pin should be placed between the drive shaft and the driven device. To obtain longer gear life, the motors should be applied so that the maximum load on a varying load cycle will not recur on the same gear teeth.

In general, these are the factors that must be given attention in the application of small motors. Other points require consideration depending on the nature of the machine and load. At this point in the design analysis, the engineer will have found which motor should be used to give the best product performance. If this motor is a standard catalog item, his job is done. But if a special motor is indicated, the designer must reconsider his selection with price in mind. He must be prepared to approximate the cost of the motor modifications before deciding whether or not the use of a special motor is economically justified.

Frame Modifications

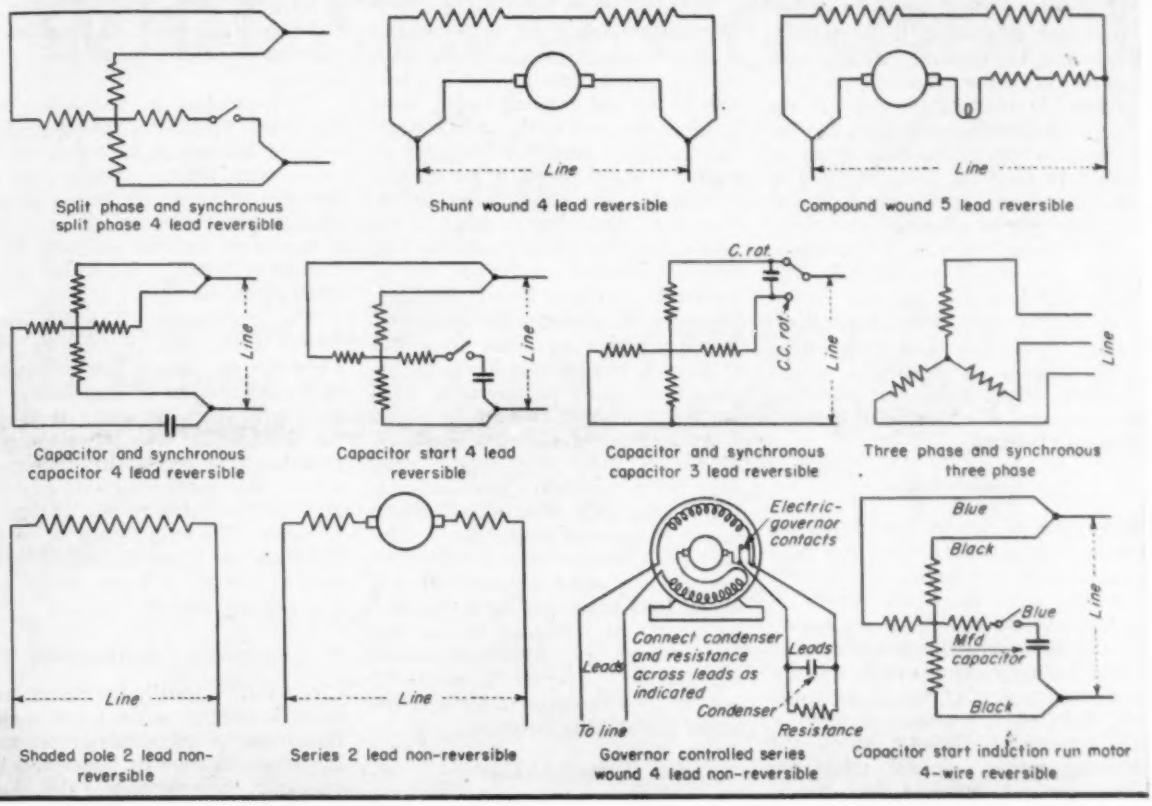
Base and frame of the conventional fractional horsepower motor are one piece. This standard frame is satisfactory for most applications such as fans, blowers, office machines, pumps and conveyors. At times, a special four piece frame structure—consisting of center ring, base and two end shields—might be specified to advantage. This arrangement enables the designer to make modifications simply. Special end shields, center ring or base can be ordered to meet the particular needs of an application. If an intergral frame structure is ordered initially, any subsequent changes that affect the frame design will be expensive.

Some motors are provided with feet or base plates rigidly attached, through which screws are fastened to the mounting surface. Others have tapped holes in bosses on the center ring to which base plates are attached. The separable base plates offer greater flexibility in mounting. Where limited space is available, the base may be omitted if the screws can be brought up from below the mounting surface.

Although the standard motor may be quiet and free from vibration, resilient mountings are available where extreme quietness and freedom from vibration is desired. The mounting illustrated above employs rubber in shear, reducing vibration to a minimum.

Another common modification to the conventional motor is the flange type end shield. This permits the motor to be supported at one end. The

Table II—Schematic Wiring Diagrams for Fractional Horsepower Motors



flange may have a rabbet in its mounting surface for centering on the driven device, insuring accurate concentricity. Studs are sometimes used for end mounting. In some small motors the screws that hold the housing together are extended. Others have studs replacing the screws holding the end shields to the center ring. These studs can project through holes in the mounting surface. The motor is held in place by drawing up nuts on the opposite side of the mounting surface. Tapped holes in the end shield is another suitable way of end mounting some small motors.

Terminal leads of small motors usually extend through an insulated outlet in the end shield opposite the shaft extension. The location of this outlet at some other point on the motor is often desired. A good example is the surgical engine shown in Fig. 1, where a special base is used to enclose a control switch. The outlet is located between the mounting bosses on the center ring. Leads then pass directly into the base. This is a relatively costly modification, feasible only when moderate quantity production is anticipated.

Control switches are available for mounting in the end shields of small motors. These may be merely on-off or forward-reverse operation switches on some types of motors. This is a relatively inexpensive modification when there is sufficient room inside the motor, so that no more machining than a drilled hole is necessary.

A great variety of shaft modifications can be obtained. The standard shaft of the smaller fractional horsepower motors usually embodies a round extension at one end with a milled flat for a set screw seat. Some of the larger motors are supplied with rectangular keyways as standard. Shafts may be any practical length or have two or more extended diameters, threads, cross holes, Woodruff keyways, squared extension or double extension. Shaft modifications are expedient for some motor manufacturers in relatively small production lots, depending on their particular manufacturing set-up.

Windings for Special Operating Characteristics

Various kinds of motors are manufactured in the frames described. Each type has certain characteristics making it more desirable for some applications than others. Wiring diagrams for commonly used types are shown in Table II.

The needs of many applications can be correctly filled by selecting motors of proper characteristics with standard windings. However, often it is more desirable to use special windings engineered for optimum power input, horsepower rating, or other special characteristics for the work in question. A better product may result.

Equipment possessing considerable inertia often requires motors with high starting torque for quick acceleration. An example of such an application is the rotary card file used in offices to facilitate handling of records. On loads of this kind the running torque under average conditions is much less than the starting torque. Other requirements of this application demand quietness, instantaneous reversibility, constant speed and operation from a 115 volt, single phase source of power. A suitable motor for an application of this kind is a capacitor motor. However, the standard capacitor motor has a starting torque of about 75 to 100 percent of the full load running torque. Therefore, the standard capacitor motor cannot be used. The designer

must investigate the following special alternates.

In engineering a stronger winding for greater starting torque, consideration must be given to the duty cycle. Otherwise, the increase in wattage input may cause the motor to exceed the permissible temperature rise. If the duty cycle is sufficiently light, the designer can specify the same frame as would be used for a motor rated to carry the normal running load. Should the duty cycle be severe or allow little time between starts, a larger motor frame size should be utilized. The latter will have less magnetic saturation and greater temperature dissipating qualities. The engineering work required to develop a special winding usually makes this procedure uneconomical if a very small quantity is to be produced.

Special Rotor

A rotor of special design can increase starting torque. This is a high resistance wound rotor. The current carrying parts in which current is induced by the stator field are usually of the same general construction but of higher resistance material. Obtaining greater starting torque by using the high resistance rotor is done at the expense of efficiency, speed and running torque. Special rotors are more costly to produce than special windings, except in large quantity production.

There are other applications where low starting torque is required to prevent damage to the motor, to the machine, or to the materials being handled. For example, a motor with low starting torque is desirable for re-winding film on a motion picture projector. The capacitor motor is suitable for this work. The low starting torque permits the reel and film to get into motion without damage.

The split phase induction motor is frequently referred to as a general purpose motor. It has a fairly high starting torque, causing fast acceleration to normal running speed. The motor is designed so that only a small fraction of a second is required to reach the speed at which the starting winding is cut out of the circuit. Should a longer time be required for acceleration, the starting winding may become damaged or burned out if overload protection is not provided. Typical applications for the split phase motor are office machines, household appliances, pumps, coin handling machines, automatic phonographs, heating and ventilating blowers.

An inertia load such as a heavy fan or blower wheel may require more time for acceleration than the starting winding of a standard split phase motor is designed to withstand. Under these circumstances a special starting winding could be provided that would have lower starting torque and be capable of remaining on the line long enough for acceleration without damage. However, it would be best to use a capacitor motor with inherent low starting torque.

Torque Motors

Some motors are built to order for specific applications. A common one is the torque motor designed to deliver a definite torque while stalled continuously without overheating or damage of any kind. These motors may be single phase capacitor, polyphase induction, shaded pole or direct current.

The purpose of the torque motor is to produce motion at the time and in the amount required by the device on which it is used. It usually is desirable to have the horsepower developed by the motor from the stalled position to maximum speed to be as constant as possible.

Torque motors are built with excellent characteristics for taking up film or tape on reels in recorders or announcement systems. The motors are designed to deliver the correct torque, placing proper tension on the film or tape as the reels are gradually filled. Danger of breakage is avoided in the reeling process.

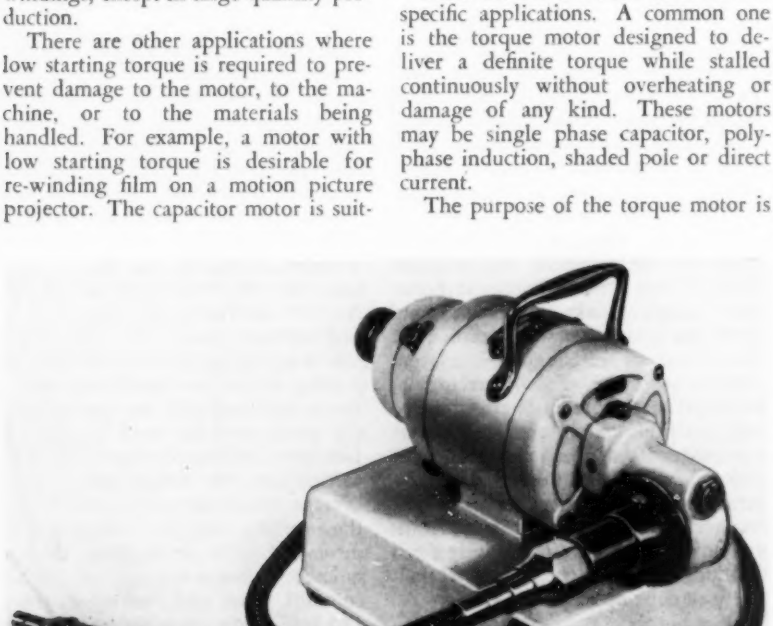
The applications on which small torque motors can be used to great advantage are many. One instance is in the manufacture of magnet wire of very small gage. A motor is needed for spooling the wire when the final manufacturing process has been completed. The spool must vary in speed as it is filled due to the change in diameter. The torque must be of the right amount from the empty spool until it is filled to insure proper tension and still prevent breakage.

Economic Considerations

Necessity is usually the determining factor in whether or not frame modifications or special windings are used in the specification of the motor, but economics enter the picture also. Even the more simple modifications illustrated should not be considered unless some quantities are involved. The facilities of some manufacturers will permit the production of motors with the most simple modifications in lots as low as 10 to 25 units. In most instances, however, where lots of less than 100 are required, it is best to design equipment around standard motor construction.

More extensive modifications require much larger quantities to be practical. The quantities will vary with different manufacturers, depending upon their production facilities.

New motor frames usually should not be considered in lots of less than 10,000 to 25,000 if die castings are used. If sand castings are used, smaller quantities may be considered, depending upon how elaborate the pattern may be. Ordinarily quantities of 10,000 motors would justify special end shields or center rings. Special shafts are feasible in lots of 100 to 1,000. Manufacturers' quotations on special motors are likely to differ considerably. It is advisable to check with several motor makers before deciding on the practicality of a special design. A motor that one company can produce only at a high price might be supplied by another at reasonable cost.



V. Mueller & Co.

Fig. 1—Flexible shaft machine for surgical use employs modified fractional horsepower motor. Special frame has integral table base, which contains line switch and also encloses the wiring to the motor. This is a costly "special", practical only in quantity.

WIRE STRAIN GAGES *for elevated temperature service*

No longer need the designer make assumptions regarding strength and loading on complex structural components operating at temperatures over 700 F, or in some instances, up to 1,500 F. Special high-temperature wire resistance strain gages, previously unavailable can be constructed for such service.

D. J. De MICHELE
General Engineering and Consulting Laboratory
The General Electric Company

THE DEVELOPMENT OF TURBO-JET ENGINES and other equipment that operates at elevated temperatures imposed new problems on designers and engineers. These problems involve the selection of the right materials to stand the temperature under repeated loads.

For satisfactory operation the designer must know the forces and stresses to which the materials are subjected, and the properties of the materials under operating conditions. Specifically, he must know.

1. The static and dynamic stresses to which the structural member is subjected during actual operation.
2. The resonant or natural frequency of the member. This is very important, especially on rotating machinery.
3. The damping characteristic of the material. (Ability of the material to dissipate energy when subjected to alternating forces.)
4. The strength of the material under static and dynamic loading.

Electric resistance wire strain gages have established themselves as a valuable tool for factory testing as well as for laboratory investigations. They are especially valuable for stress measurements on structures subjected to complex loading, particularly since they are small in size, need not be bolted or welded to the equipment, can easily be adapted for measuring stresses in fillets and around sharp contours of structures, and have excellent response to high frequency dynamic loading.

At present, two basic types of gages are available commercially. Both are known as SR-4 wire resistance gages and are manufactured by the Baldwin-Southwark Division of the Baldwin Locomotive Works. One gage is bonded with a nitro-cellulose cement and used for work up to approximately 100 F. The other type, bonded with a synthetic resin, is used for work at higher temperatures. It is mounted with a synthetic resin and baked under pressure through a specified heating cycle to polymerize the cement. Although the maximum temperature recommended by the manufacturer is 350 F, synthetic resin gages have been successfully used, in some cases, up to temperatures of 700 fahrenheit.

For these latter applications, a special bonding technique is used since the resin becomes a semi-conductor. An undercoating of a special high temperature cement is first baked on the structure to which the gage is to be cemented. The undercoating cement is brushed or sprayed on and allowed to harden by passing a torch or gas burner back and forth over it, while slowly increasing the temperature of the flame. After this procedure, the synthetic resin gages are bonded to the cement following the same procedure as specified by the manufacturer for applications up to 350 F. The gages have good adherence to the undercoating, which, in turn, provides an insulation against low leakage resistance to ground.

At present, however, there are no commercially available wire resistance strain gages which can be purchased for use in the temperature range of 1,000 to 2,000 F. For measurements in this range, the stress analysts are building their own gages, constructing the gage on the structure where measurements are to be made.

But there are numerous problems that arise during the manufacture and application of gages for this temperature range. These problems can be classified under three major categories: Selection of the gage wire, selection of the bonding cement, and development of the leads between the gage and the recording instruments.

A suitable resistance wire must have:

1. As high a sensitivity as possible. Sensitivity is indicated by the gage factor, which is mathematically defined as follows:

$$\text{Gage factor} = \frac{\frac{\Delta R}{R}}{\frac{\Delta l}{l}}$$

where ΔR = change of resistance
R = total resistance of gages
Δl = change of length of wire
l = total effective length of wire

2. High resistance per unit length,

This condition makes possible the manufacture of small physical size gages with higher total resistance.

3. A linear strain-resistance change up to high strains.

4. A known temperature coefficient of expansion. This fact is particularly important where only one gage is to be used.

5. Weldability. The thermo-electric effects of the welded joint between the gage wire and lead wire must be avoided.

6. A suitable size-resistance ratio, since the size of wire must be such as to have a good bond between wire and cement. The smaller the wire diameter the better the bonding will be.

7. Flexibility, so that it can be easily handled during manufacture.

After a suitable wire has been selected based on the above properties of certain gage wires, the next step is to select a bonding cement to withstand this temperature.

The requirements of the bonding cement are most important and are the most difficult to fulfill. It must:

1. Withstand high temperatures without carbonizing.

2. Have good adhesion qualities to all materials.

3. Have a thermal expansion as nearly as possible to the one of the material being tested.

4. Cure at temperatures that are sufficiently low as not to affect the characteristics of the test material.

5. Be free of fillers or binders that might chemically or electrolytically attack the wire at any temperature.

6. Not become a semi-conductor at high temperatures.

7. Prevent oxidation between the metal and cements. Oxidation usually causes the cement to flake off the specimen.

8. Be adhesive to prevent a drawn out mounting technique with a number of different cements.

9. Be easy to handle and sufficiently flexible so that it can be formed on complex contours of the structure.

A high temperature gage was first reported by Carl Schabtach and Dr. R. O. Fehr in their paper "Measurement of the Damping of Engineering Materials During Flexural Vibration at Elevated Temperatures" in the *Journal of Applied Mechanics*, Volume II, No. 7, June, 1944, pages A86 to A92.

This gage consisted of 0.0015 in diameter Nichrome wire fabricated as a multiple grid on a thin undercoat of Sauereisen Cement No. 31, manufactured by the Sauereisen Company. The undercoat provided insulation for the gage wire. The wires were held in position with human hair and a second coat of Sauereisen No. 31 was then brushed over the gage wires and leads to hold the gage on the structure. These gages stood up satisfactorily at 1,100 F for an indefinite period of time. They lasted for from one to two hr at 1,300 F, and long enough for a test at 1,400 F. They were mounted on turning forks. Useful information on damping characteristics was obtained at elevated temperatures.

S. S. Manson, R. H. Kemp, and W. C. Morgan, in their paper "High Temperature Strain Gages and Their Application to Measurement of Vibratory Stresses in Turbo Supercharger Buckets" in the *Proceeding of the Society for Experimental Stress Analysis*, Volume V, No. 1, pages 90 to 100, reported successful results obtained with high temperature strain gages. Their problem was more difficult to solve, since the strain gages had to operate on turbine buckets in an active gas turbine. The cement, gage, and wiring technique had to withstand the force of the blast, and high centrifugal forces caused by high peripheral speeds at the gage location. The authors used several different types of gages: a straight filament type, V-type, multiple-loop type, and form type. The gage wire they used was Nichrome V, and Sauereisen No. 1 was the cementing medium. Their paper describes the method of fabrication, their calibration technique, and circuits used, and information obtained on their tests of the supercharger buckets.

R. E. Gorton and R. W. Pratt, in a paper entitled "Strain Measurements on Rotating Parts", presented before the Society of Automotive Engineers at their annual meeting in January, 1949, also did valuable work toward the development of a high temperature strain gage. Their technique consisted of fabricating Nichrome V wire gage on the surface of a strip of celluloid. A Quigley Triple *A* high heat resisting paint, Green No. 1900, manufactured by the Quigley Company, Inc., was coated over the wires. The gage was then transferred from the celluloid to the structure while the cement was pliable, and bonded to the structure by applying additional Quigley paint to the specimen.

The technique of building and mounting all of these homemade high temperature gages requires a considerable amount of manual dexterity and skill. In many cases a large number of gages must be installed to obtain one satisfactory gage. Also, the gages must be fabricated directly on the structure, or, if fabricated on a jig, they must be transferred immediately to the structure and bonded.

For this reason, work on a high temperature gage which would lend itself to factory production and simple mounting technique has been undertaken. The General Electric Company is now using a high temperature gage as shown in Fig. 1. This gage is fabricated on a jig in the laboratory. It can be stored, and later applied to a structure where high temperature stress measurements are to be made. It consists of an 85 percent platinum—15 percent iridium wire, fabricated on mica in a closely spaced flat grid. The filament wires are held in suspension with Sauereisen cement No. 31 on the mica sheet, and the gage can be transferred from the mica to the specimen and bonded with additional cement.

Platinum-iridium wire was selected for this particular gage because of its high sensitivity. The gage factor is between 5.8 and 6 at room temperature, which is approximately three times the gage factor of Nichrome V. In addition, this wire lends itself to the measurement of stresses at high frequency. Other properties are: Wire diameter, 0.0008 in.; resistance, ohms per ft, 250; tensile strength, hard, 90,000 psi; tensile strength, annealed, 55,000 psi; BHN, hard, 185; BHN, annealed, 130; temperature coefficient of expansion 0.0013 between 10 and 100 C; melting point, platinum, 1,773 C; and melting point, iridium, 2,454 C.

Platinum-iridium is not affected by high temperatures in air and is not attacked by single acids or alkaline carbonates, although hot concentrated sulphuric acid will attack it slightly.

Various types of Sauereisen cement were experimented with to obtain the results sought. In these tests, No. 31 seemed to perform the best. Since the physical filler particles of this cement are fairly small, a better bond can be obtained between the cement and the structure.

Some electrolytic and chemical action takes place at high temperatures and with time causing breakdown of the electrical insulation properties where prolonged use of the gage is anticipated; precoating the structural material with some chrome oxide will reduce this action. The chrome-oxide also prevents oxidation from forming between the cement and the metal. Another cement, which was developed as an undercoating for the Sauereisen cement, also lends itself as an insulation between the Sauereisen and the structural material.

The primary application of these gages has been for high frequency measurements. A typical use is illustrated in Figs. 2 and 3, which show respectively the method of mounting

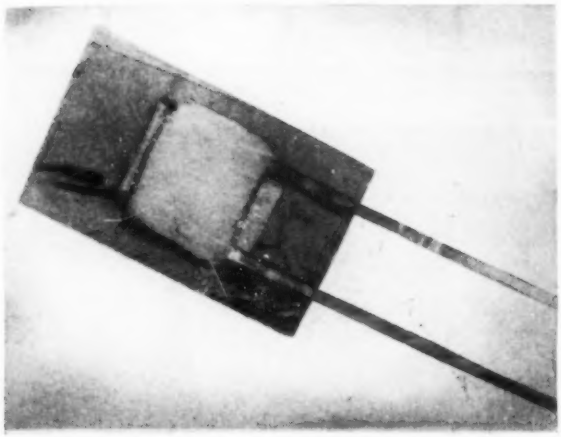


Fig. 1—Newly developed high temperature (1,500 F) strain gage consisting of a platinum-iridium grid bonded to mica.

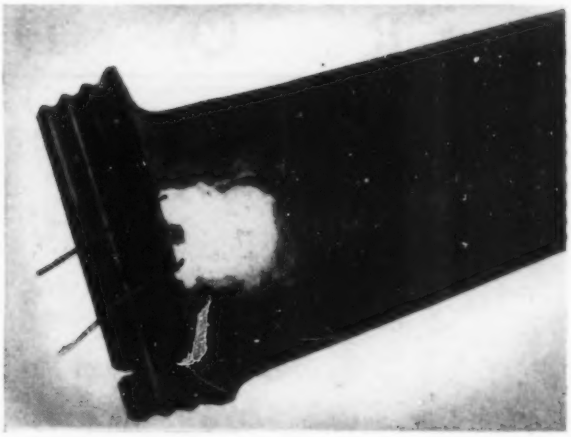


Fig. 2—Typical mounting of a high temperautre strain gage on a turbine bucket. The gage is bonded with Sauereisen cement.

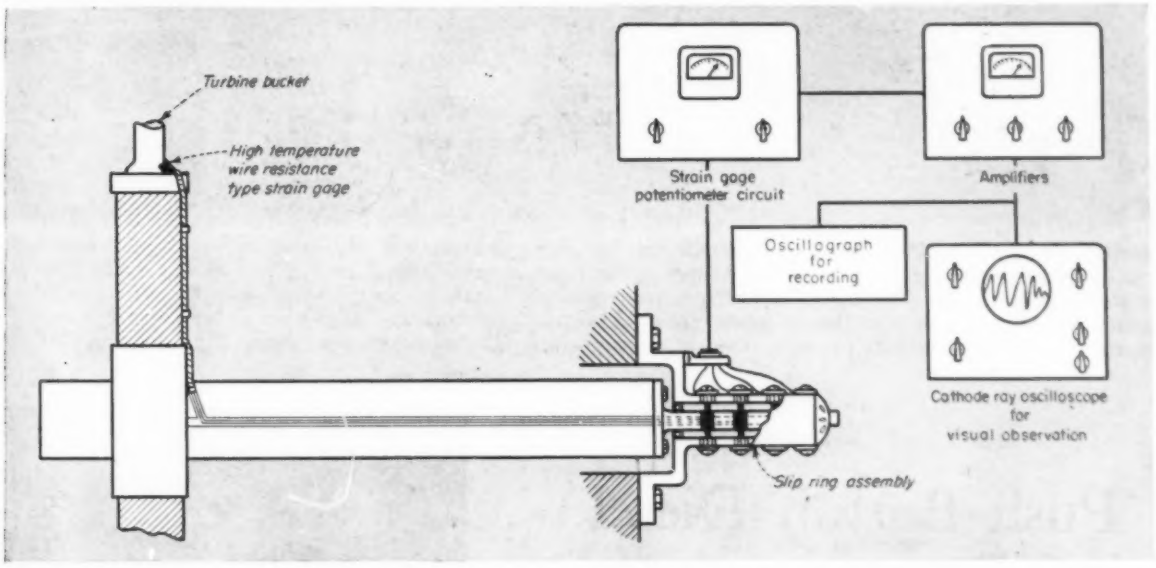


Fig. 3—Set-up for measuring dynamic strains on a turbine buc ket. Special precautions must be taken in bringing out the leads.

a gage on a turbine blade, and a set-up for measuring high frequency strains.

For measurements under conditions such as shown in the sketch, the problem of high centrifugal forces is also important. The selection of the lead wires and method of mounting to the wheel must be considered.

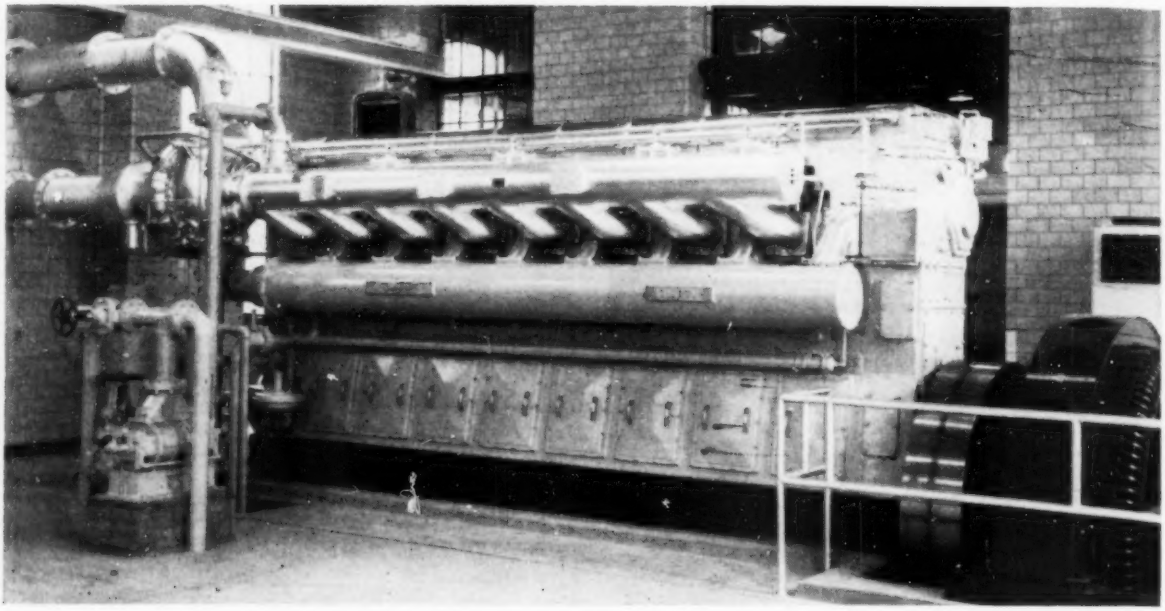
The lead wires from the gage to the slip ring assembly shown in the illustration consist of stainless steel tubing with two conductors insulated from each other, either with fibre glass sleeving or with magnesium oxide powder. The stainless steel tubing is held against the wheel with clips that are spot welded to the wheel. After completion of the tests, the chips can easily be chipped off and any irregularity on the surface can be sanded down. Drilling and tapping of holes is not recommended for a high-speed wheel.

The lead wires are brought through the center of the rotating shaft and connected to the slip ring assembly. Needless to say, the slip ring and brush assembly design is very important, since on it rests the success or failure of a project of this type. The slip ring material, which has given satisfactory results, is coined silver, and the brushes are made of 85 percent silver and 15 percent graphite.

The brush spring material should be steel, since other materials anneal at too low a temperature and loose their spring pressure due to the temperature between the brushes and the slip rings—these temperatures in some instances being as high as 400 F. The spring pressure applied to the brushes determines the life of the brushes, the heat generated, and the overall performance of the assembly. Special precautions in alignment and the assembly, also determine the minitype of coupling between the shaft and mum spring pressure that can be used. Misalignment can cause brush bouncing which, in turn, will result in erratic results and make difficult the reading of values.

When the slip ring and brush assembly are used in high ambient temperatures and no air circulation is present, special cooling must be provided. The most effective method of cooling is to circulate clean filtered air inside the housing around the brushes. In some applications, where this is not feasible, the unit can be cooled by supplying air or oil through cooling tubes mounted around the shell of the slip ring housing.

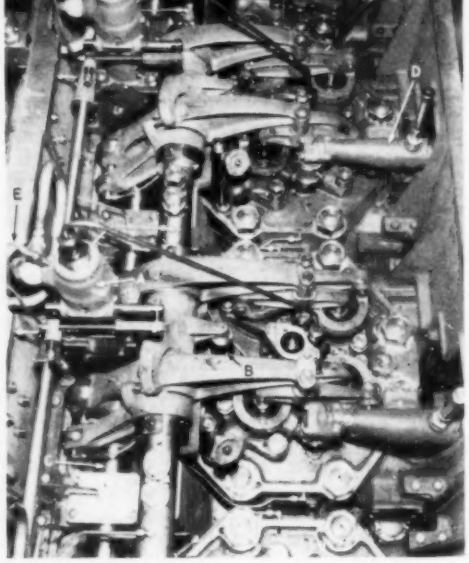
The overall performance of the slip ring and brush assembly for every application is determined by the careful design of all its components.



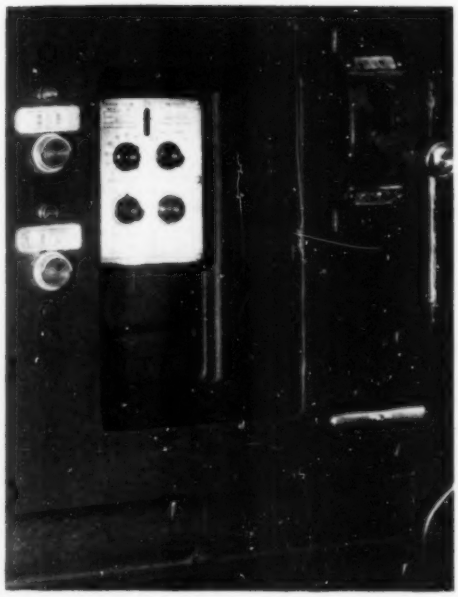
MODEL 80 DUAL FUEL DIESEL ENGINE can be either naturally aspirated or supercharged, with power ratings up to and beyond 1,000 hp. The above Superior diesel uses not only natural gas and fuel oil, but is also operating on sewage or sludge gas. The supercharged engine presents a special problem in the introduction of gaseous fuel since it cannot be fed directly into the air intake manifold, as usual, without large losses when each cylinder is scavenged. Superior solves this problem by using the air starting check valve already in the cylinder head to admit fuel gas.

Push-Button Diesel Uses Fuel Oil or Gas

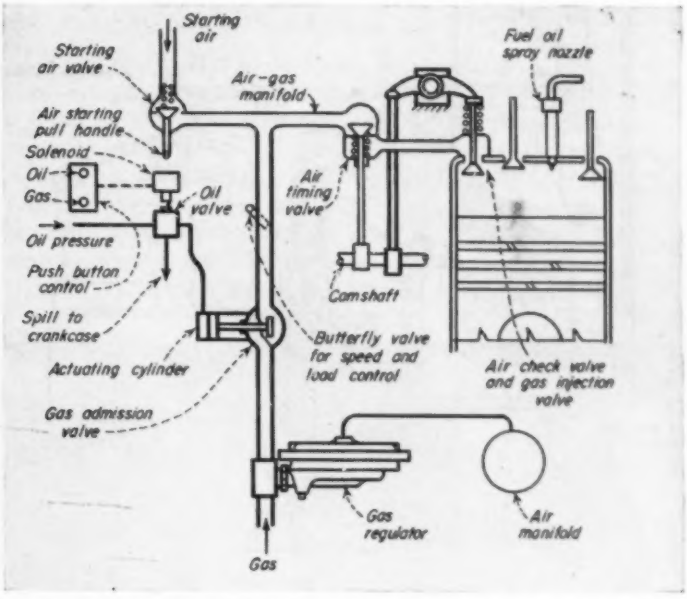
The ability to operate on almost any combustable gas, as well as fuel oil or combinations of gas and fuel oil, is the outstanding feature of the Model 80 "Superior" diesel engine. Controls are kept to a minimum. Control panels have only two push buttons, one for oil and one for gas, and two signal lights, one amber and one white. Fuel is selected by merely pushing the "oil" or "gas" button, with one of the two signal lights indicating the type of fuel being used. Since dry gases will not ignite at the engine compression of 400 psi, a small pilot charge of fuel oil is injected at the proper time to ignite the gas. An automatic pilot oil control is operated by the governor so that any shortage in the gas supply will be made up by injecting more fuel oil. The governor will permit burning of all available gas before injecting the extra fuel oil. The amber signal light will show that oil in excess of pilot capacities is being used. The Model 80 "Dual Fuel" push-button diesel engine is made by the Superior Engine Division of the National Supply Company, Springfield, Ohio.



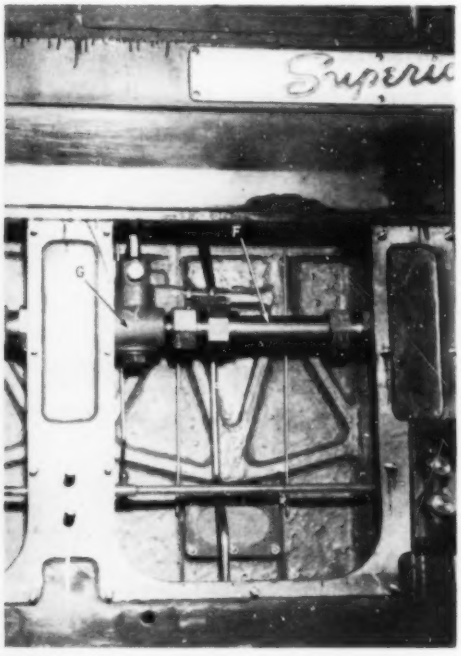
CLOSE-UP of the supercharged engine shows oil injection pumps (A); the starting air check valve (B); the camshaft (C); a cooling water connection (D); and an air bleeder (C) which removes air from injection system.



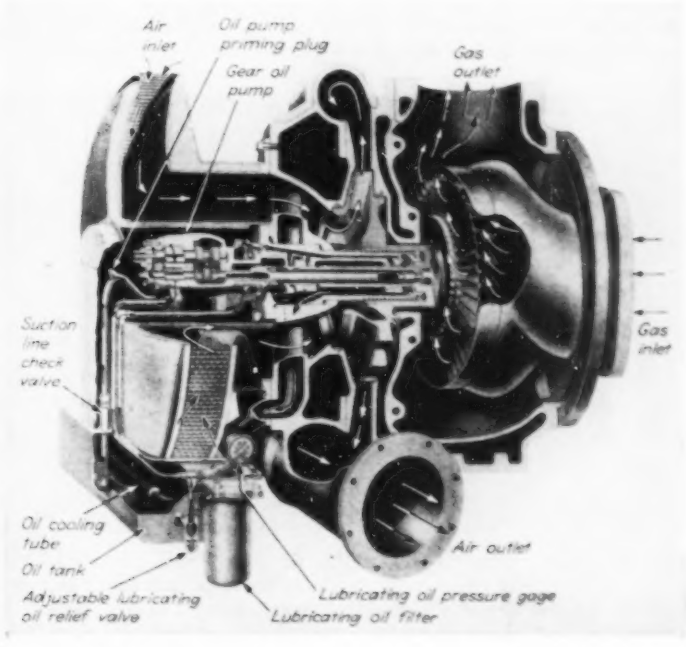
CONTROLS ARE CENTERED in this panel, which contains an "air starting pull handle," lower right; a "stop"-"run" lever; and a "gas" and an "oil" push button, each with a signal light. These few controls operate the engine.



SCHEMATIC DRAWING shows the basic principles of dual-fuel operation. Pressing the "gas" button closes a switch which energizes a solenoid operated pilot valve. This valve admits oil pressure to the cylinder of the gas shut-off valve, which opens the valve and admits gas to the engine. The "air starting pull handle" admits compressed air.

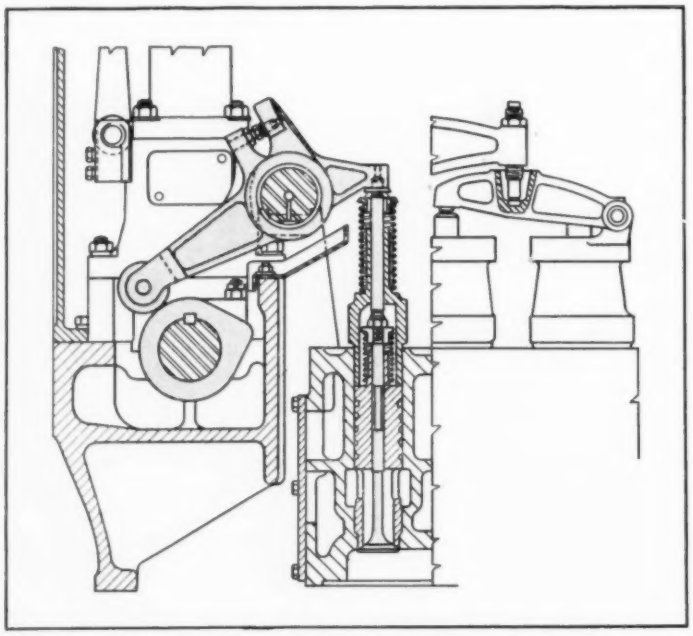


COMBINATION STARTING AIR and gas header (F) transmits compressed air during starting and gas during dual-fuel operation. The air starting valve assembly (G) has a built-in gas proportioning valve.

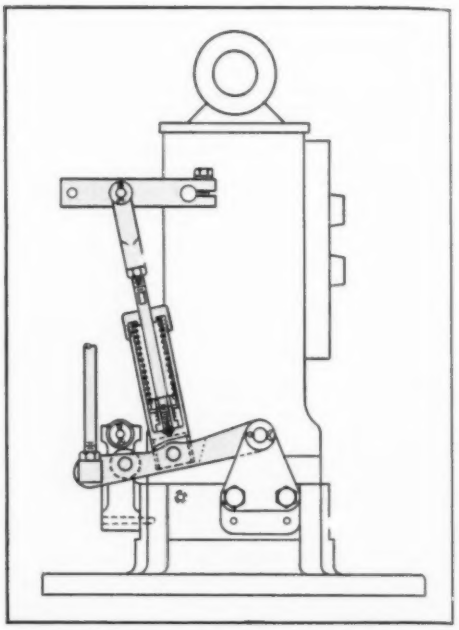


A SUPERCHARGER of this type can raise the power output of the 960 hp engine to around 1440 hp. This is a 50 percent increase in power with only about a 15 percent increase in weight. The weight per hp is reduced about 40 percent. Increased power is obtained with only slight increase in cylinder pressure. (*continued on next page*)

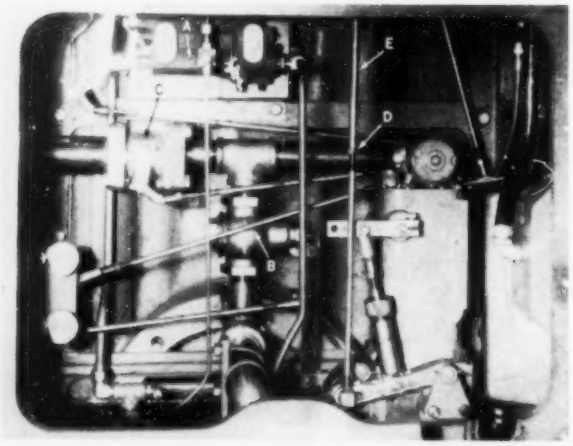
Push-Button Diesel (continued)



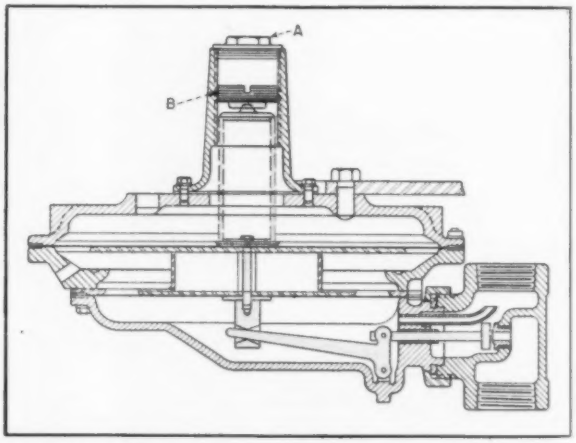
GAS IS DISTRIBUTED to the cylinders by using the air check valve in the cylinder head as a gas injection valve. The large cam, driven by the camshaft, impinges on the cam follower and operates a lever. This lever acts, in turn, on another lever which opens the air check valve. The valve is timed to open when the engine exhaust valve closes, and to close when the intake valve closes. Thus gas enters the cylinder only while combustion air is being taken in. The gas injection valve clearance can be reset to conform with the clearances of intake and exhaust clearances. The engine starts on fuel oil, and runs on oil alone until the gas is introduced. The fuel oil consumption is then reduced.



AUTOMATIC PILOT OIL CONTROL is operated by the governor through the above linkage. When the fuel supply is switched from oil to gas the governor reduces fuel oil injection as soon as the gas has traveled from the shut-off valve to the engine. In dual-fuel operation the pilot fuel oil is about 5 percent of the amount used in full diesel operation. A special hydraulic acceleration element, above, provides extra oil injection for sudden loads.



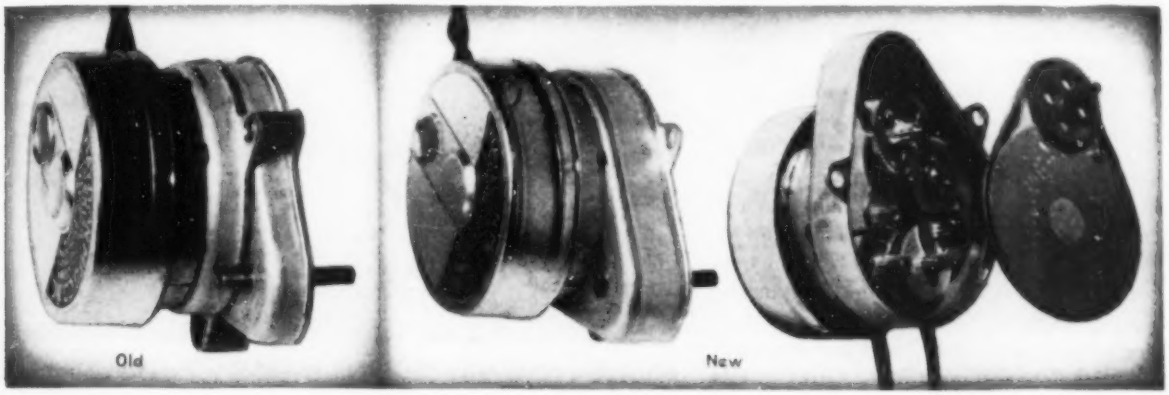
DETAILS OF FUEL CONTROL MECHANISM are shown above. The governor positions the air throttle through the medium of a hydraulic booster cylinder (A). During starting, the starting air valve (B) is opened by pulling the starting handle. When the handle is released a spring closes the valve. When the gas shut-off valve is opened, gas passes through a governor controlled butterfly valve (C) and into the header. The total amount of pilot fuel oil may be adjusted by loosening the nut (D) and turning (E), the pilot oil adjusting rod.



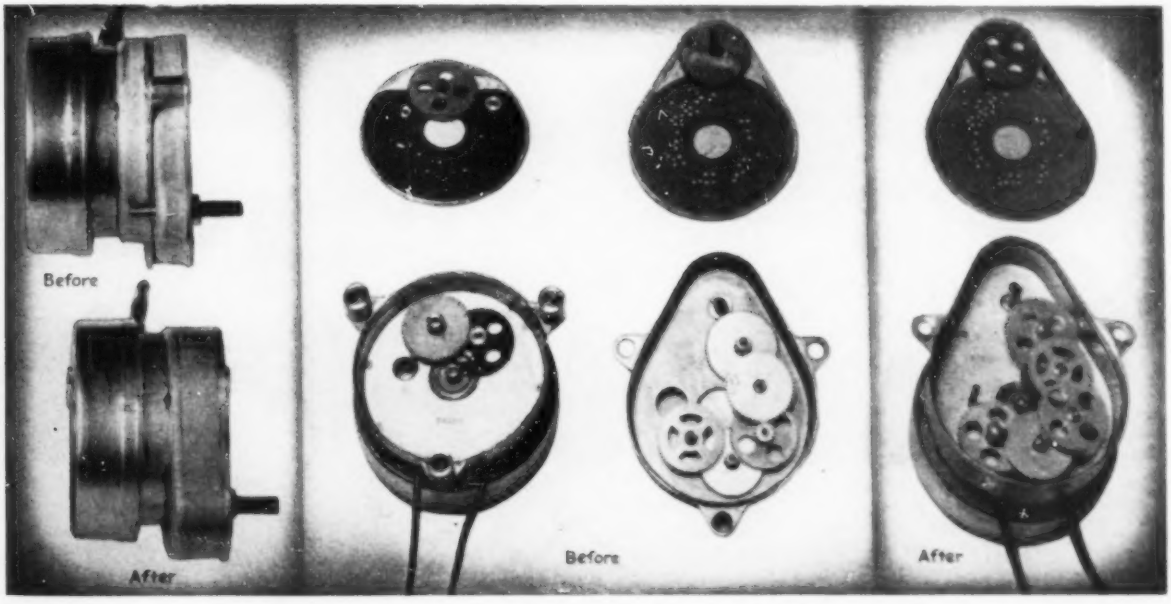
SPECIALLY BUILT GAS REGULATORS, above, supplied as part of the engine. They act in addition to the regular gas pressure regulating valve installed in the gas supply line and set to regulate delivery pressure to about 15 psi. They make final pressure adjustments after regular regulators approximate requirements. These special regulators can be adjusted by removing the plug (A) and turning the adjusting screw (B), running the screw down to increase pressure, and vice versa. This adjustment must be made when full gas supply pressure is available.

Simplicity, Key to Motor Redesign

When the Haydon Mfg. Co. of Torrington, Conn. was faced with urgent demands several years ago to meet immediate market demands for very slow speed motors there was no time to go back to fundamentals of design. The situation required that they use what was available, with the only criterion being satisfactory performance. Existing motors which ran at relatively high speeds, in the range of 60 rpm to 1 rev per hr, were adapted to fit the extremely slow speeds of 5 to 1,000 hrs per revolution. The company subsequently began an intensive redesign study which yielded some of the following results: (1) reduction in size; (2) cost reduction due to simplified manufacturing procedures and reduction of parts; (3) interchangeability with existing motors of different output speeds, and; (4) a more pleasing appearance resulting from compact, functional design. The main design improvements are shown below.



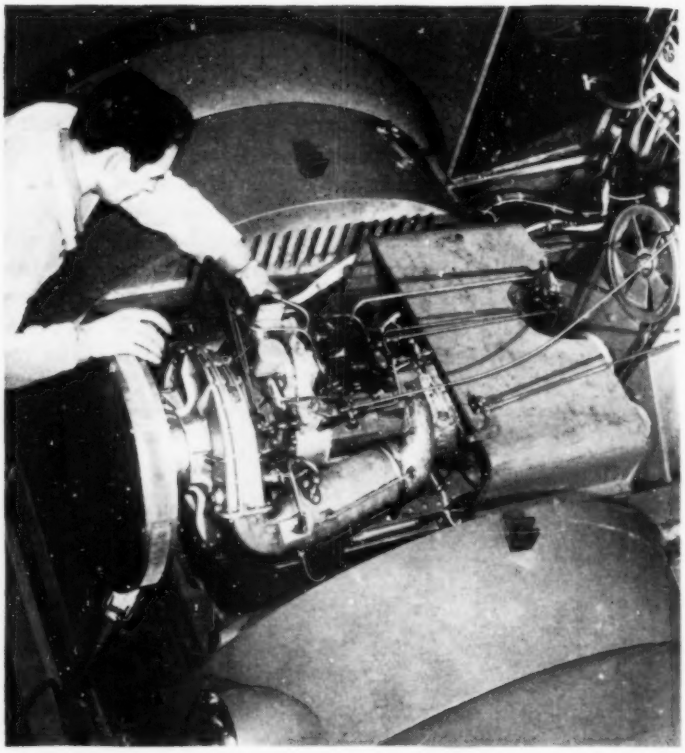
OLD DESIGN, on left, was a combination of an existing motor from one series and a gear train from another series. While it gave satisfactory service, size, appearance and cost were drawbacks. The new 4400 series, right, uses a slightly deeper gear cup and a new type of gear train to get much slower speeds in little more space. The train is assembled on two levels, on common studs, with an anti-friction plate between the two sets of assemblies.



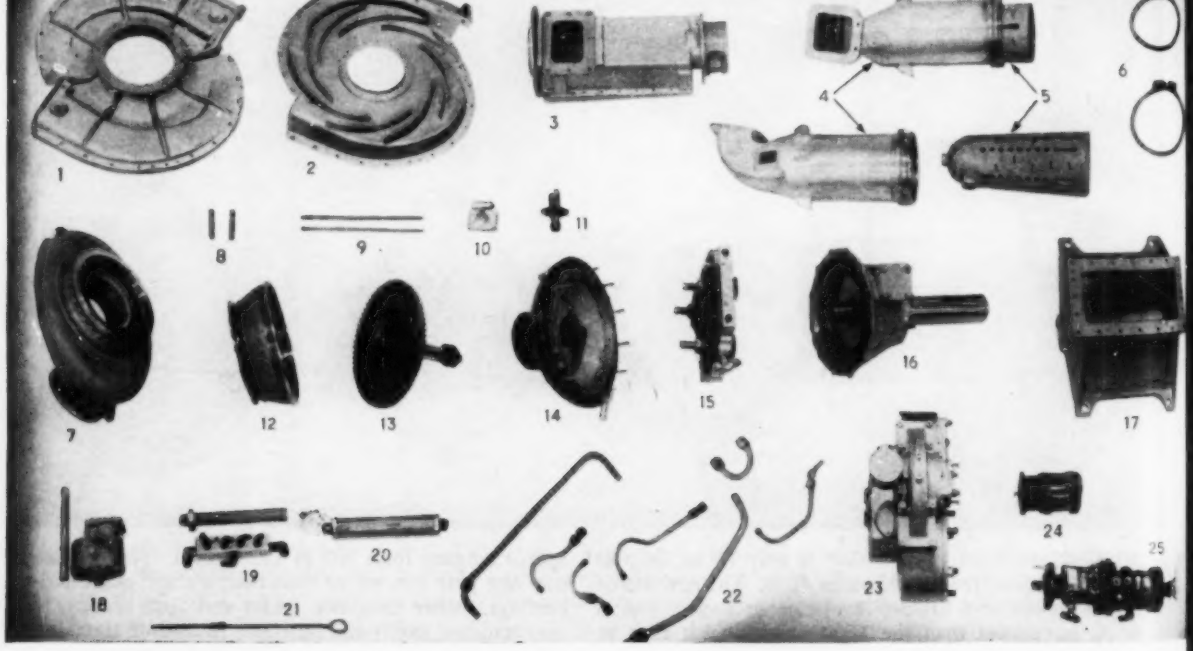
THE NEW MODEL, series 4400, is only $1\frac{3}{8}$ in. deep as compared to $1\frac{1}{2}$ in. for the old series 4100. The new motor produces speeds of 6 hrs per revolution or slower, and is only $\frac{3}{16}$ in. deeper than the 1600 series, which runs at speeds ranging from 300 to 1/240 rpm. The new design uses one gear cup, rather than two; a single shaft and two bearings, rather than two shafts and four bearings; and uses standard shafts and bearings, instead of specials.

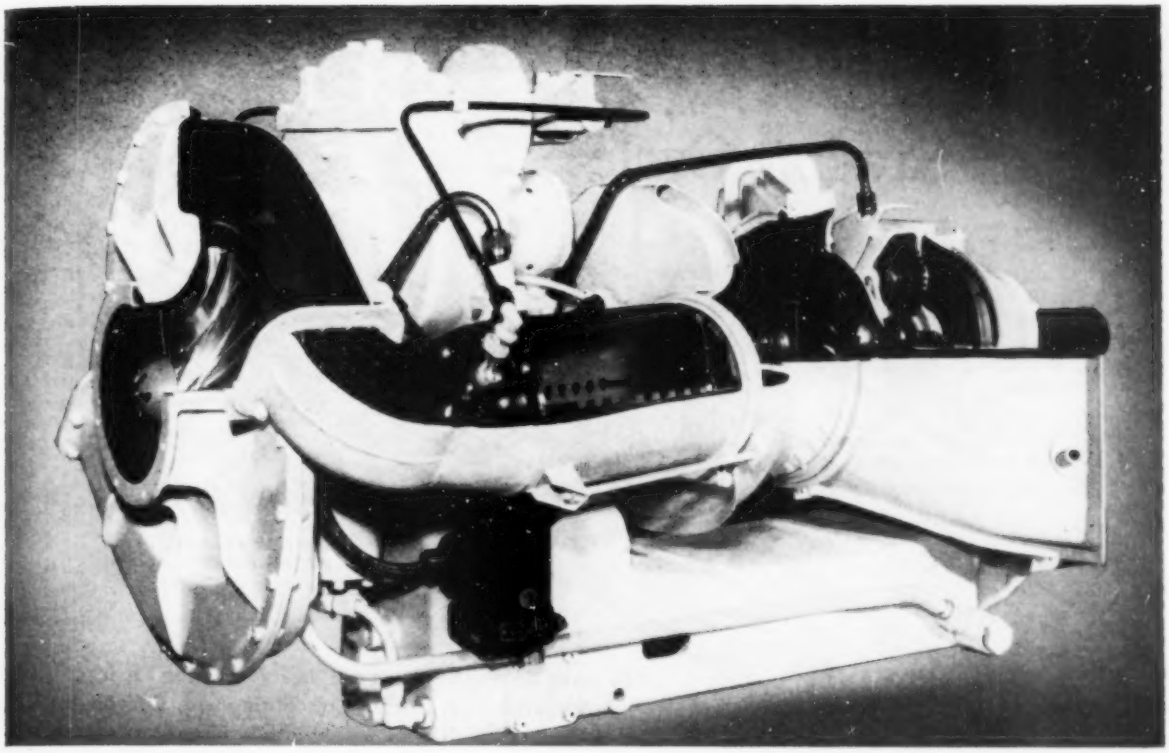
Boeing Builds Automotive Gas Turbine

As previously reported in PRODUCT ENGINEERING in June 1950, page 145, the Boeing Airplane Co., Seattle, Wash., has built and tested an experimental gas turbine for automotive and other uses. The new engine weighs only 200 lbs, and develops 175 hp. The new engine now uses about twice as much fuel as a gasoline engine, and about three times as much as a diesel engine. However, it can use a cheaper grade of fuel oil, and Boeing expects to cut present fuel consumption in half. The new engine has two major sections: a gas producer and a power-out-put section. The gas producer has a single-stage compressor, two burners, and an axial flow turbine wheel. Gases travel from the first-stage turbine wheel, which turns 36,000 rpm, through a nozzle box, and are expanded through the second-stage wheel which drives the output shaft.

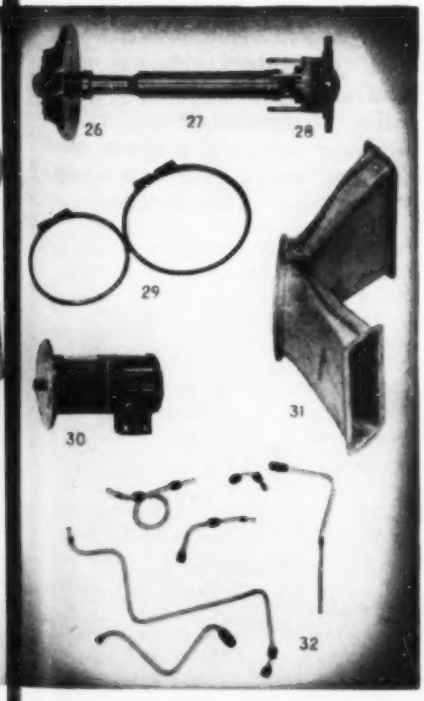


BOEING'S NEW GAS TURBINE ENGINE is shown installed in a Kenworth truck. It is not yet in quantity production. Exhaust gases are about the same temperature as those from a diesel or gasoline truck. At idling power, for instance, it is possible to place a hand over the end of the exhaust pipe without danger of being burned. Exhaust gases are virtually invisible, and have no offensive odor.





CUTAWAY MODEL of the new gas turbine shows the comparatively simple construction. The power producing section, in front, has a turbine wheel turning at about 36,000 rpm. The second-stage wheel turns at 22,500 rpm and drives through a 9 to 1 reduction gear, stepping the speed down to 2,500 rpm and producing a continuous output shaft rating of 175 hp. For power braking the second-stage wheel reverses while the first-stage turns as usual. The turbine is simpler in construction than the conventional engine, having only from 1/5 to 1/10 as many moving parts as a diesel and no sliding parts. When it goes into quantity production manufacturing costs will be less than for the piston engine.



(1) Front half compressor case—made of cast aluminum.

(2) Back half compressor case—cast aluminum.

(3) First stage housing—cast aluminum.

(4) Burners—stainless steel.

(5) Burner liners—also stainless.

(6) Clamping rings—steel.

(7) Collector and first stage nozzle box—stainless steel and cast vanes.

(8) Oil jets—steel.

(9) Stay rods—steel.

(10) Fuel injector nozzle—steel with a brass nozzle.

(11) Ignition plug—standard purchased part.

(12) Shroud and second stage nozzle—stainless steel and cast vanes.

(13) Second stage turbine—Timken alloy 16-25-6 hub and special high strength alloy cast blades.

(14) Front half, reduction gear housing—cast aluminum.

(15) Gear assembly—steel gears with an aluminum diaphram.

(16) Rear half, reduction gear housing and shaft—cast aluminum and steel.

(17) Oil sump—cast aluminum.

(18) Oil pump—has aluminum case and steel gears.

(19) Oil system manifold—aluminum.

(20) Oil strainer—aluminum and steel.

(21) Oil gage—steel.

(22) Oil system lines—aluminum.

(23) Accessory drive box—aluminum housing and steel gears.

(24) Electric tachometer generator—purchased part.

(25) Fuel pump and governor—purchased part.

(26) Impeller—machined from an aluminum forging.

(27) First stage shaft—machined from SAE 4130 steel.

(28) First stage turbine—has Timken alloy 16-25-6 hub and blades case from special high strength alloy.

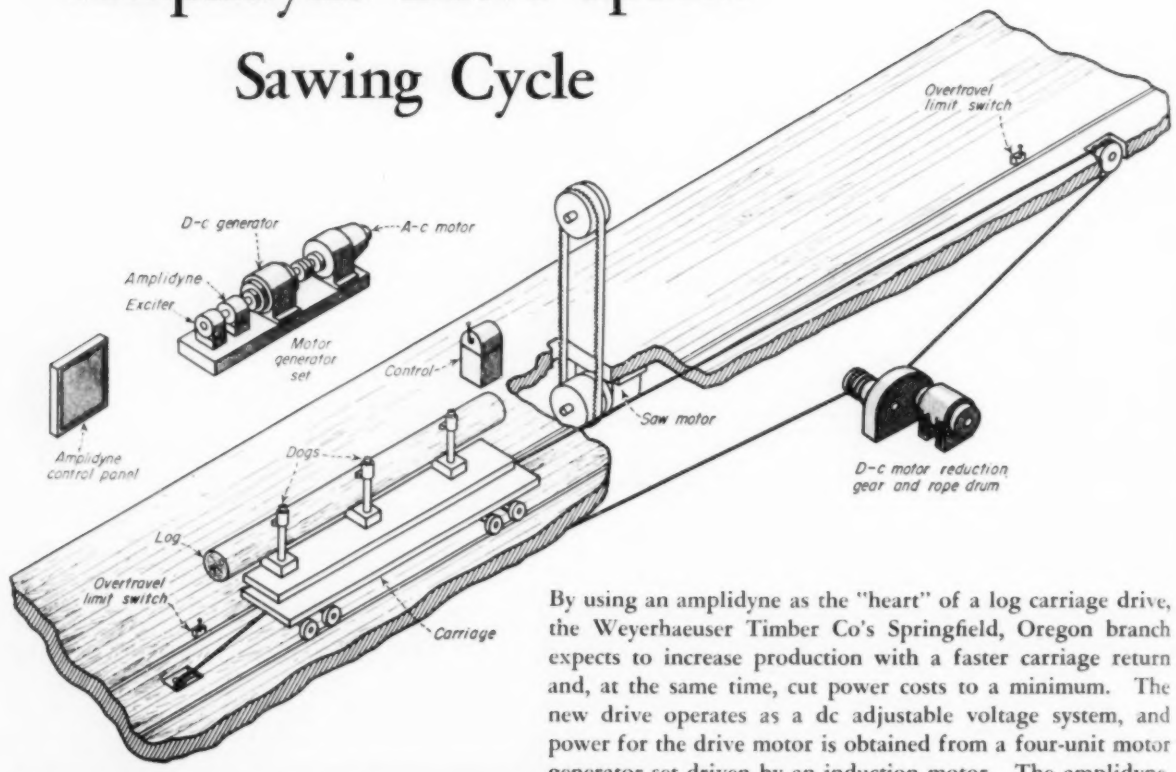
(29) Clamping rings—steel.

(30) Starter and generator—purchased part.

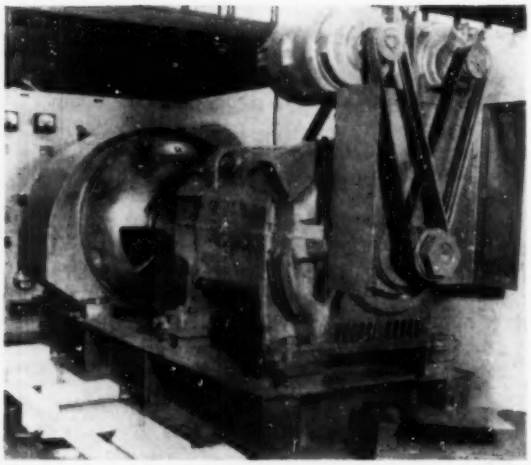
(31) Exhaust diffuser — stainless steel.

(32) Fuel system lines—aluminum tubing.

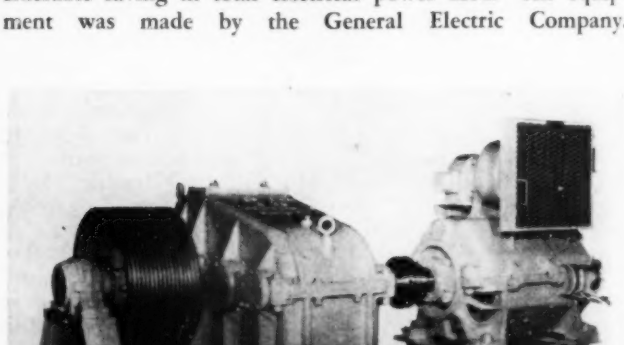
Amplidyne Drive Speeds Sawing Cycle



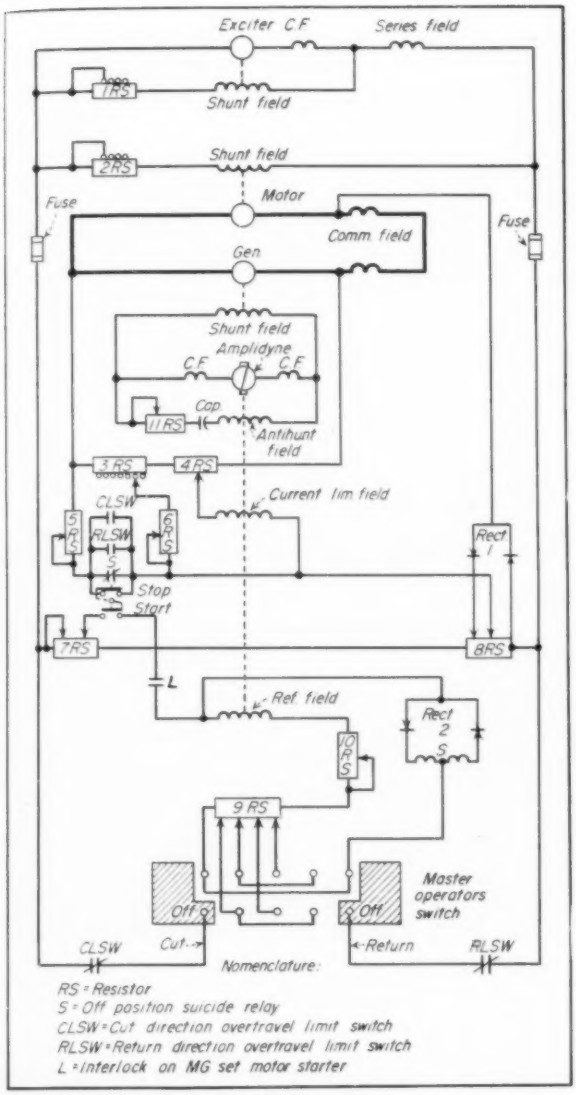
By using an amplidyne as the "heart" of a log carriage drive, the Weyerhaeuser Timber Co's Springfield, Oregon branch expects to increase production with a faster carriage return and, at the same time, cut power costs to a minimum. The new drive operates as a dc adjustable voltage system, and power for the drive motor is obtained from a four-unit motor generator set driven by an induction motor. The amplidyne, similar in appearance to a small motor, acts as a dc amplifier with very high amplification. It establishes a simple electrical balance which allows the smallest electric signals to release relatively great output. The new amplidyne-controlled system replaces the steam "shotgun feed", which wastes steam, and the slower "twin engine" steam drive. Among other features, the amplidyne allows current generated by the inertia of the heavy carriage during deceleration periods to be fed back into the regular power lines, which effects considerable saving in total electrical power used. All equipment was made by the General Electric Company.



HEART of the new sawmill carriage drive is this four part motor generator set having a 400 hp induction motor, a dc generator, and (top) a 5 kw exciter and 5 kw amplidyne. The amplidyne control panel for this drive is simple and inexpensive and has no regularly moving parts.



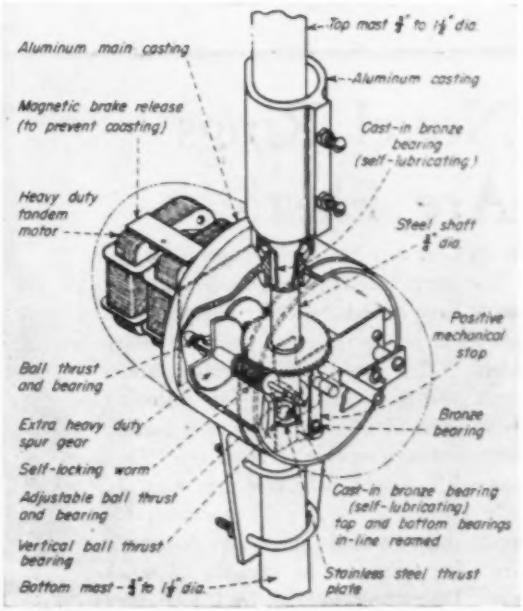
THIS CABLE DRIVE UNIT draws its dc power from the motor generator set. The unit includes an enclosed and ventilated dc motor and a Western gear reducer. The motor will withstand heavy mechanical strains, and high voltage.



SIMPLIFIED WIRING DIAGRAM shows operation of the system. With fixed field excitation applied to the motor, the carriage speed is essentially proportional to the applied armature voltage. The armature voltage, supplied by the generator, may be changed by adjusting the generator field current. Therefore, the carriage speed increases as the generator field current is increased and decreases when the generator field is decreased. Also, the direction of carriage travel is reversed simply by reversing the current direction in the generator field. Field exitation for the generator is supplied by the amplidyne. The voltage output of the amplidyne is a function of the net ampere-turns produced by the three amplidyne shunt fields. The fields are the "reference", the "current-limit", and the "anti-hunt" fields. When the sawyer moves his master control switch, in effect, he is changing the number of ampere-turns contributed by the reference field, which changes the amplidyne output voltage. The resulting change in generator voltage would be nearly instantaneous if it were not for the current-limit field, which limits motor and generator armature current to a safe value. Thus the resulting rate of armature voltage change (carriage speed change) is the maximum that can be safely handled by the equipment.

TV Antenna Rotator

One of the latest accessories in the television field, this new antenna rotator has a plastic control box and a weatherproofed, all aluminum motor-driven unit mounted outdoors on the antenna mast. The plastic control box comes in two types, above, with one model registering antenna direction, and the other, less expensive, merely indicating the end of antenna travel. Plastic parts are molded by the Emeloid Co., Inc., Hillside, N. J., with a flame-resistant cellulose acetate furnished by Hercules Powder Co. Emeloid make the control box for U. S. Devices Corp., South Plainfield, N. J., who manufacture and sell the complete rotator. The outside power unit has a heavy-duty tandem motor which rotates the antenna through a 370 deg arc. The unit operates on 110 V current. It is expected to cut down on ghost images and other distortions that are frequent when the receiving television antenna does not face a sending station squarely.


Top mast ¾" to 1½" dia.
Aluminum main casting
Aluminum casting
Magnetic brake release (to prevent coasting)
Cast-in bronze bearing (self-lubricating)
Heavy duty tandem motor
Steel shaft ¾" dia.
Positive mechanical stop
Ball thrust and bearing
Bronze bearing
Extra heavy duty spur gear
Self-locking worm
Adjustable ball thrust and bearing
Cast-in bronze bearing (self-lubricating) top and bottom bearings in-line reamed
Vertical ball thrust bearing
Stainless steel thrust plate
Bottom mast - ¾" to 1½" dia.

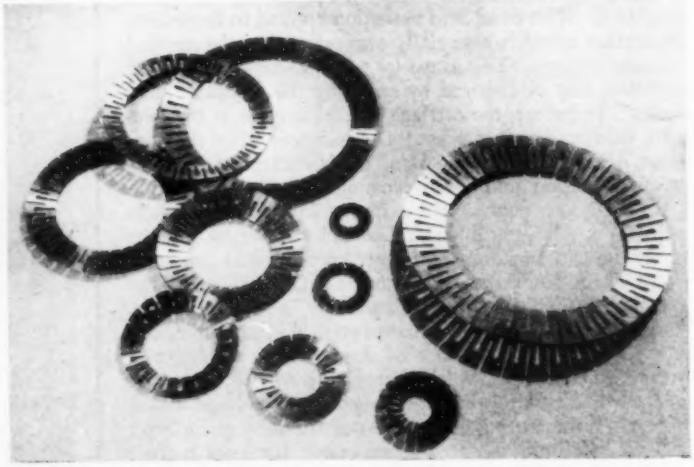
Trailer Hitch Designed for Sales Appeal

The "Tour-aid" trailer hitch assembly was first made as a weldment. Then, when the mechanical success of the pilot model had been assured, the entire unit was redesigned from the viewpoint of appearance, sales appeal, and mechanical strength. The welded design had a "home-made" appearance that affected its sales appeal; so the manufacturers called the Unicast Corp., of Toledo, Ohio, in as consultants on the redesign. Taking the unit one part at a time, Unicast engineers converted the whole assembly into steel castings. The Steel Founder's Society of America reports that the new all-cast design effected a weight saving, a machining cost saving of 75 percent, and a total finished cost saving of 20 percent. Extensive tests show the resulting product to be considerably stronger than the original welded design. The manufacturer reports an unusual amount of orders for the product, which confirms the value of the redesign.

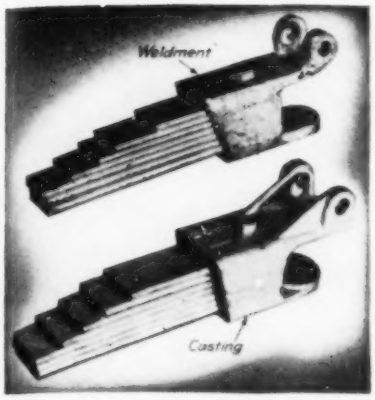
COMPLETELY REDESIGNED trailer hitch, above, has more sales appeal as well as greater strength than the previous all-welded model. Also, as a weldment, the fixturing of pieces was costly.

Novel Rings Are Elastic

Made in Germany by the Ringspann Co., of Bad Homburg V.D.H., these novel machine elements have a slightly conical shape which causes them to increase in diameter when flattened. This quality of expanding under pressure makes them useful for fastening machine parts to a shaft, as a radial sealing element, or radial tension element, etc. They are especially useful where a part must be quickly replaceable. A milling cutter, for example, must be held tightly and accurately on its arbor, and yet be capable of quick change. Distributed in U. S. by J. P. Bayard and Co., New York City.

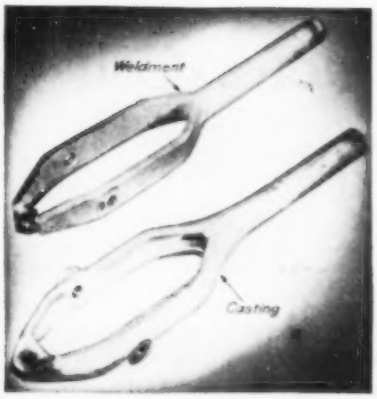


ASSORTMENT OF RINGS illustrates the variety of sizes made. The radial slits in the diameter of the rings give them the elastic property. Rings are usually used in groups to provide a larger expanding surface.

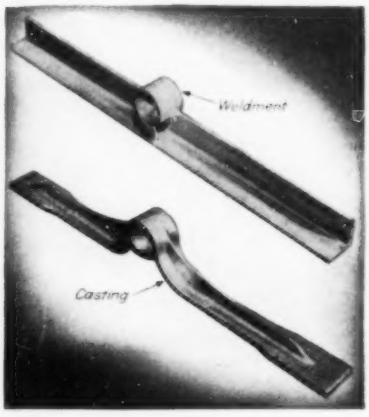


THIS TOW-BAR PINION UNIT was hard to position for welding. This was the first part to be redesigned.

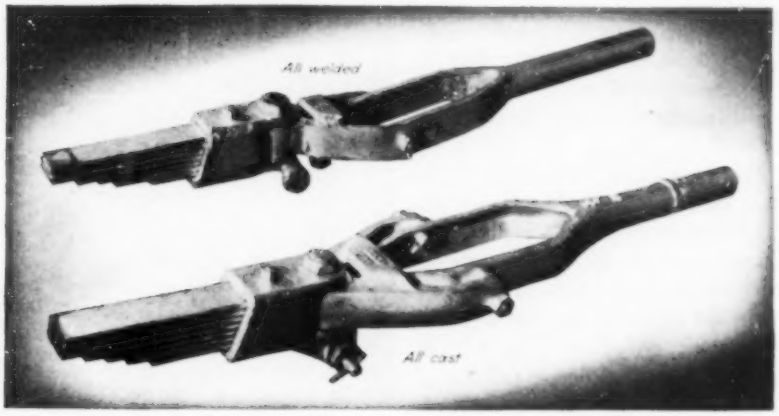
PINION YOKE has greatly increased strength as well as better appearance. **Critical sections are stronger.**



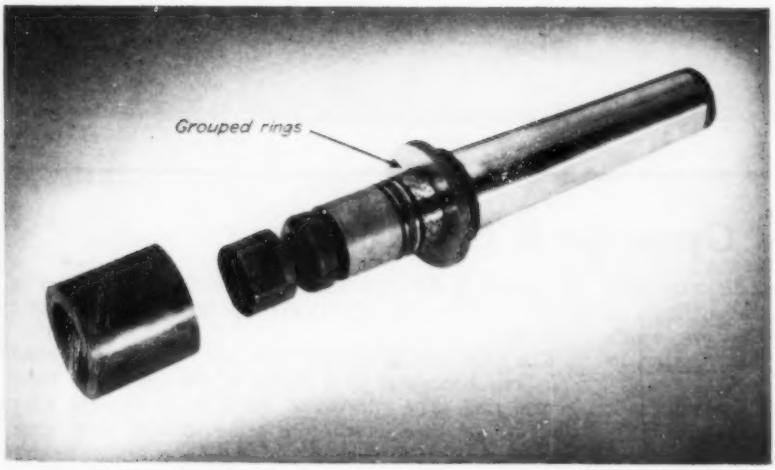
REAR YOKE was made stronger at several important points. This piece looked "home-made" when welded.



YOKE CARRIER is important structural member. After redesign it lost the "makeshift" look that it had.



IN ADDITION TO APPEARANCE, the company reports tests loadings which prove the increased strength of all parts. One part was loaded to 8,000 lb without deformation while its fabricated counterpart was deformed at 1,500 lbs.

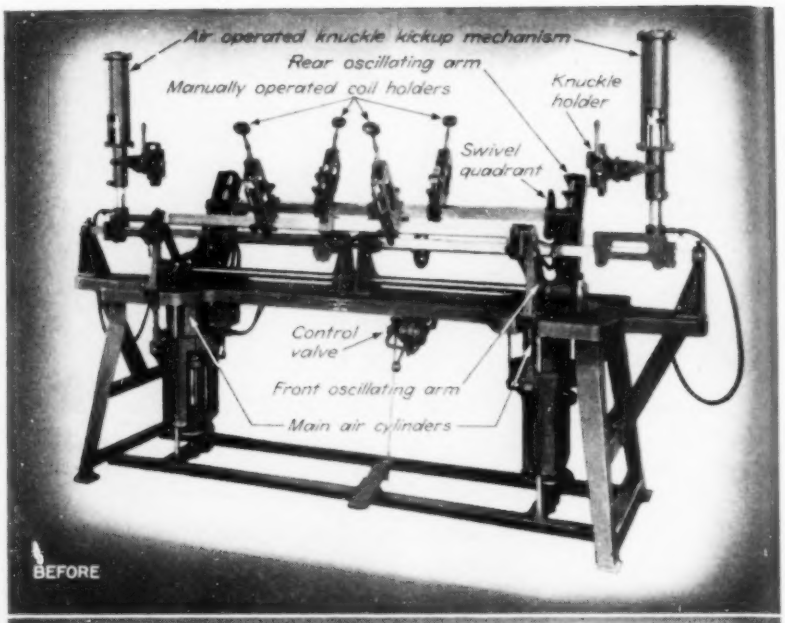


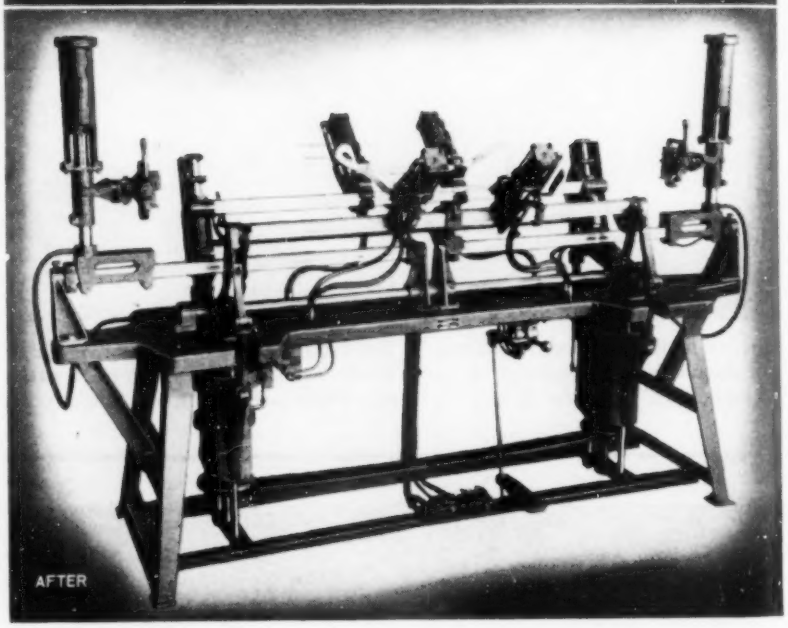
ARBOR has about a dozen expanding rings grouped together. When collar is placed around the rings, and the nut is screwed down flat and tightened, the rings expand enough to grip collar tightly.

ONE EXPANDING RING effects a tight seal in this food container. Screwing down nut expands ring.

Motor-Coil Spreader Is Automatic

Automatic, air operated coil spreading machines are the latest development of Potter and Rayfield, Inc, of Atlanta, Ga. These coil spreaders, which form coils into the exact shape they will occupy in the armature or stator, are usually manually operated. In the company's newest models, by eliminating eleven parts in the cam operated manual coil holder and using two main air cylinders as well as mounted coil holder air cylinders, a high-speed machine has been developed which has a high degree of accuracy. Of the two designs shown, at right, the top cut shows an interim design that has the two main air cylinders, but not the coil holder air cylinders. The bottom cut shows the completely redesigned coil spreader. Another innovation is that the coil holder bars are made to swivel on their axes, making it possible to form coils whose included angle may range from zero to 150 deg, with coil spreads from 4 to 21 in. On former manually operated machines the grip on the coils to be spread was from top to bottom. In the redesigned unit the coil is gripped on four sides.



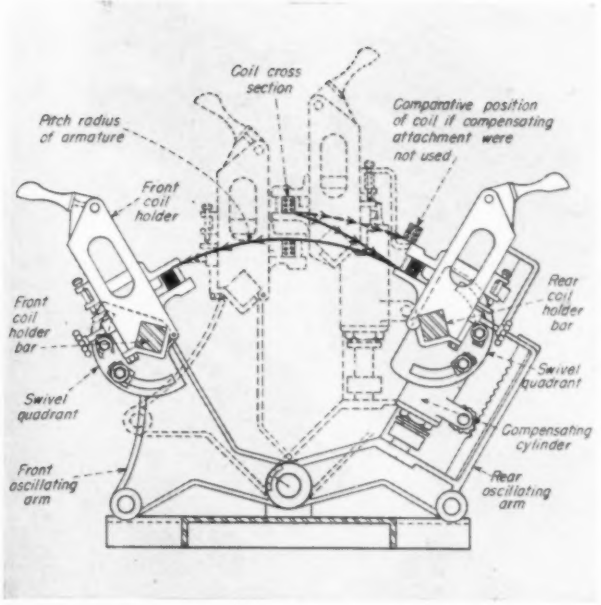


Air Driven Gyroscope is Non-Toppling

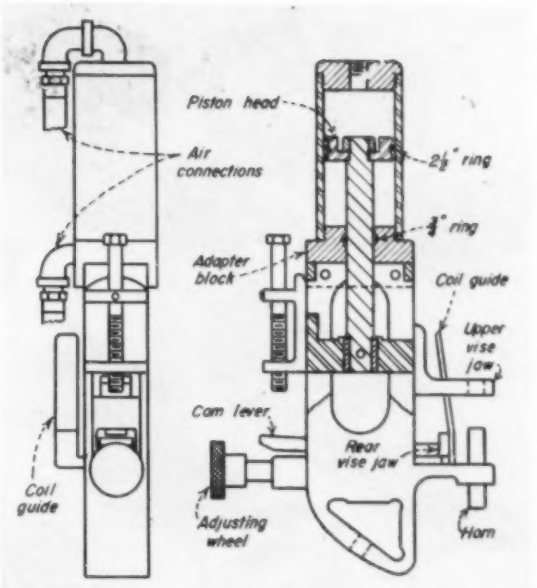
To meet the need for a "non-toppling" direction indicator, Smiths Aircraft Instruments Ltd., London, England, has recently developed an air-driven directional gyro which has complete freedom of the inner gimbal ring up to 85 deg.

This instrument, which is virtually fully aerobatic, is consequently ideally suited to the needs of training aircraft, when the pupil may be made conversant with the presentation he will meet in operational aircraft and where aerobatic maneuvers may be made without toppling the gyro. The instrument is equally suitable for airline use where an air-driven direction indicator is considered necessary as a stand-by to the electrically operated gyro magnetic compass.

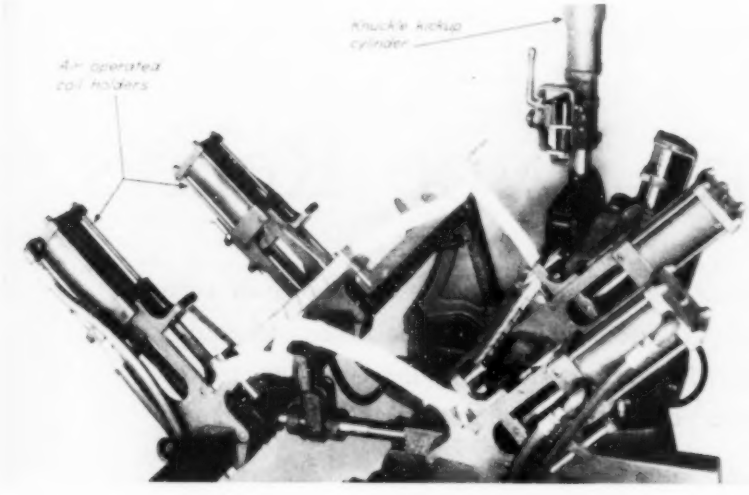
The rotor runs in ball bearings and is mounted with the spin axis horizontal in a casing which forms the inner gimbal ring. The rotor wheel has a heavy tungsten alloy rim, the periphery of the rim being serrated. The rotor wheel center has a co-efficient of expansion similar to that of the rotor case, therefore temperature variations have little effect on bearing adjustment. The rotor is dynamically balanced and provision is made for the static balancing of



COIL SPREADING PRINCIPLE is illustrated above. When coils are spread by main air cylinders a compensating cylinder pulls coil into correct position on the armature pitch radius.



AIR OPERATED COIL HOLDER eliminated eleven parts formerly used in the cam operated manual coil holder. Coil holder construction is shown above.



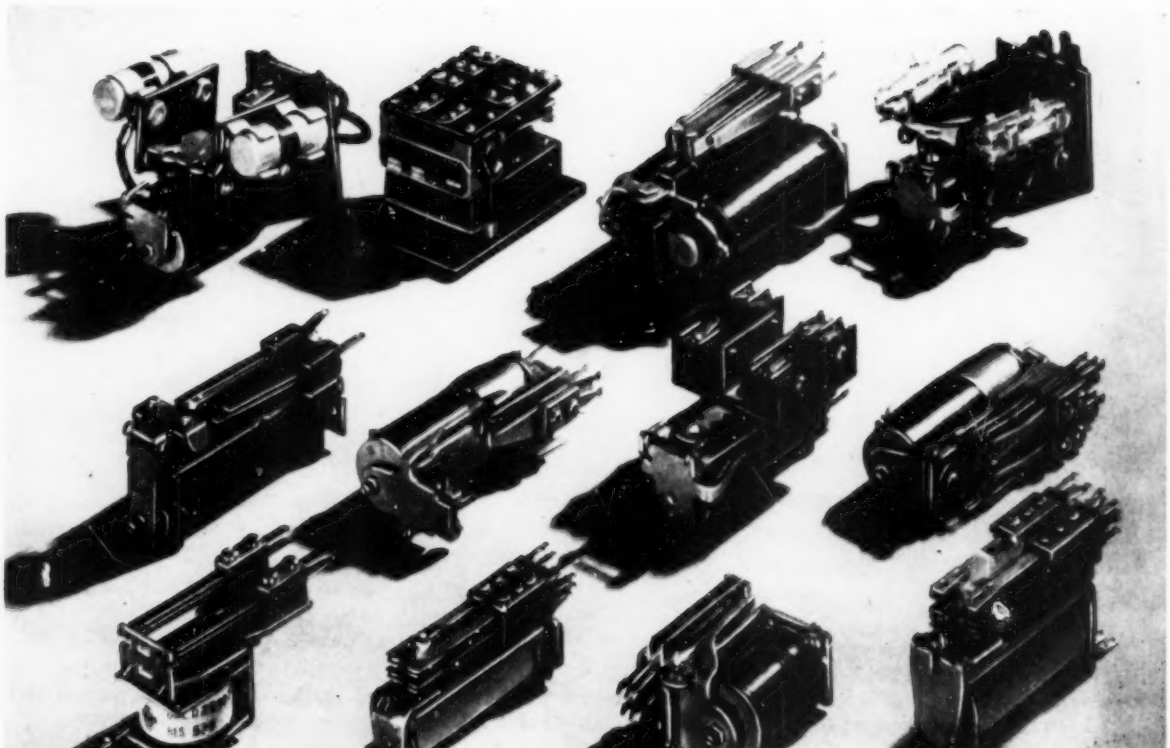
MAIN SPREADING ACTION is controlled by the hand or foot operation of a four-way air valve which actuates the double-acting cylinder below the table of the machine. A hand operated valve in the center is used to actuate the knuckle kickup cylinder, which raises the end of the coil to correct position. All air cylinders were especially designed for the new machine. Compensating adjustment and interconnection of air lines permit simultaneous operation of all cylinders. Air operation eliminates the eight manual operations of opening and closing the four coil holders during loading and unloading. The coil guide, mounted on the two front coil holders, facilitates loading of coil into the holder. The holders grip the coil.

the rotor case. The rotor case is horizontally pivoted in ball bearings in the outer gimbal ring which, in turn, is pivoted about a vertical axis in the instrument frame. A semicircular baffle attached to the outer gimbal ring is aligned with erector jets in such a manner that, when the case and the spin axis of the rotor are horizontal, the orifices of both jets are partially and equally shrouded.

Special differential gearing is used between the gyro gear on the outer gimbal and the compass card to enable the card to be reset, under any flight conditions or on the ground, without caging the gyro. The dial setting knob which is geared into the differential train for this purpose is situated at the 4 o'clock position on the instrument dial.

The course setting pointer is operated independently from the central knob on the instrument dial and a reduction gear of 7:2 ratio is provided between the knob and the course setting pointer to facilitate accurate setting of the pointer.

The fixing holes are so positioned that the instrument can be interchanged readily with existing types of gyro direction indicators; a larger cut out being all the modification necessary to accommodate the larger dial. The new gyroscope is air driven and operates on a suction of $3\frac{1}{2}$ to $4\frac{1}{2}$ in. of mercury, applied to the instrument case.



TELEPHONE TYPE RELAYS are designed in many types of constructions, mounting arrangements, and contact spring assemblies.

Telephone Type Relays

Electrical and mechanical details that influence the choice of type of electro-magnetic relay to use for control of machines and equipment. Advantages and limitations of telephone type and power type relays are compared on the basis of design and performance.

V. E. JAMES
Staff Engineer, Industrial Control Division
Automatic Electric Company

A FEW BASIC PRINCIPLES govern the design of all electro-magnetic relays. When an electrical current passes through a conductor, a magnetic field is created that varies in intensity not only with the amount of current but also with the properties of the adjacent medium. The magnetic field produced by a given current flowing through a conductor surrounded by iron is much denser than the field produced around the same conductor when the surrounding medium is air.

Within wide limits, whether in air or a superior magnetic medium, the intensity of the magnetic field is proportionately increased by each turn added to a coiled conductor. A relay's magnetic strength is therefore commonly stated as the number of ampere-turns. With enough current flow, any desired strength can be produced by even a single passage of the conductor. But for practical and economic reasons, relays usually have coils of many turns.

Some materials are magnetized and attract other magnetic materials only while an exciting current flows in a nearby conductor. They produce no appreciable magnetic attraction after the current ceases. Such materials have low (magnetic) retentivity. In contrast to these, other materials remain magnetized after the exciting current ceases to flow.

All electro-magnetic relays have three basic parts: (1) A current carrying winding to convert electrical energy into magnetic energy; (2) An iron, or other magnetic material, member (called an armature, clapper, or plunger) that is magnetized by the field surrounding the current carrying winding in a manner such that mechanical force is produced; (3) Means of transferring the armature into work output, which is usually achieved by the making and breaking of electrical contacts.

These three basic parts are shown in

simplified form in Fig. 1. An input circuit of one or more turns of the electrical conductor, when excited, produces a magnetic field that pulls the armature downward at the end near the coil. The armature rocks about a pivot while restrained by a spring. When the input circuit is energized, the armature closes electrical contacts in the output circuit. The coil core and the heelpiece or yoke provide a return path of magnetic material.

Even the best of low retentivity electro-magnetic material has some residual magnetism after de-energization of the coil. Therefore, to prevent the relay failing to restore after de-energization, the armature is usually not allowed to strike fully against the coil core. An air gap is maintained even in the fully attracted position by means of a non-magnetic residual stud, or adjustable screw.

If the current flow in the coil is reduced to zero and then built up in the opposite direction, the magnetic field will also return to zero and be reestablished, but with its polarity reversed. This reversal of polarity, however, does not normally affect the operation of the simple relay.

The basic parts of a telephone type relay are identified in Fig. 2. The coil is wound on a spool consisting of a coil core, front and rear spoolheads (cheeks) and terminals. The coil is fastened to the heelpiece by a screw. The heelpiece serves as a mounting for other relay members. The armature has a fixed bearing pin and pivots in the armature yoke. In the pileup of fixed and movable contact springs, the springs are separated from each other by insulators, and the movable springs rest against each other with their spring buffers in contact.

Electrical contact is made between springs when the armature presses the movable springs, through an insulating member called an armature buffer, against the fixed springs. The stroke of the armature is limited by a backstop. The residual gap between the armature and coil core is maintained by the residual screw.

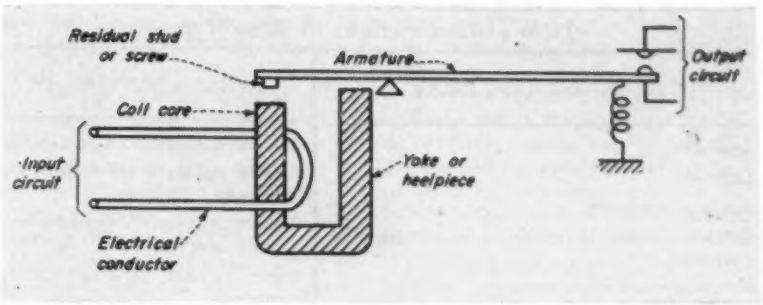


Fig. 1—Parts basic to all electro-magnetic relays, with input and output circuits.

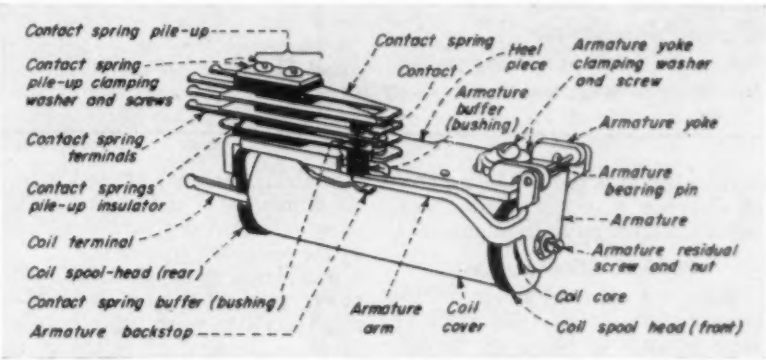


Fig. 2—Nomenclature applying to the structural parts of telephone type relays.

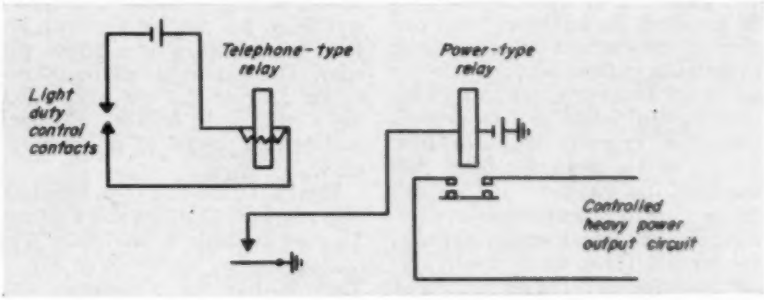


Fig. 3—Telephone type and power type relays cascaded to obtain a high degree of power multiplication, where range is greater than either relay alone can provide.

Telephone Type and Power Type Relays

In this discussion of both the telephone type and the power type relays, it should be clearly understood that each has features giving it preference for some particular industrial application; each likewise has limitations not found to an equal degree in the other. Furthermore, to achieve the best over-all applications, the two types often should be used in combination, in a way such that the advantages of one will complement the shortcomings of the other.

In an application where only a delicate pair of contacts is employed for control of the relay circuit, a suitably chosen telephone type relay will perform efficiently without excessive deterioration of the control contacts. For the same application, a power type relay, because of its relatively greater power consumption and higher value of inductance, would likely result in shorter life of the controlling contacts than would be acceptable. In addition, welding and resultant sticking of the contacts might make the system inoperative long before any deterioration of the contacts was visible. The telephone type relay irrespective of its type of contacts does have less maximum contact load capacity than the heavy duty power type relay.

Assume, for example, that the system shown in Fig. 3 is controlled from a pair of contacts capable of handling 10 milliamp at a potential of 10 volts, and is connected to a controlled circuit of 230 volts, 15 amp inductive load. The power multiplication range (0.1 to 3450 watts or 34,500 to 1 ratio) is greater than either relay alone can provide. This range starts below the reach of the power type relay and ends above that of the telephone type relay. The required high degree of power multiplication is provided with good circuit results, however, when the two types are used in cascade.

A comparison of the general advantages and limitations of each type of relay is given in Table I. There is, of course, some overlapping of charac-

Table I—Characteristics of Relay Types

TELEPHONE TYPE RELAY	POWER TYPE RELAY
Smallness	Maximum power handling capability
Lightness	Ease of making heavy external connections
Response sensitivity	Contact maximum dependability in heavy load circuits
Contact maximum dependability in low potential circuits	High creepage insulation readily provided
Maximum speed of operation	Ruggedness of appearance
Readily tailored in regard to contact form and arrangement to meet specific applications	
Maximum range in timing	
Maximum mechanical life	
Not usually limited in mounting position	
Vibration and shock compensation readily provided	

teristics that leaves such a listing open to challenge in certain specific cases; but the facts are generally as presented.

Physical Considerations

Since the chief advantage of the power type relay is its ability to handle large amounts of power on its contacts, the size of this relay is dictated in large degree by the size of contacts and the amount of insulation that must be provided. At maximum rated current the contacts must be large enough to maintain current density (amp per sq in. of contacting surface) below certain critical values, in order to avoid fusing or excessive resistance from heating of the contacting faces. Furthermore, if a maximum of "creepage distance" is to be maintained to guarantee freedom from flashover and leakage currents (or to satisfy Underwriters' requirements), certain spacing of insulation and airgaps between contacts is essential.

Because of these factors, the power type relay is usually larger than the telephone type relay. Also, to provide accessibility for heavy external wiring, the terminal sizes and spacing require more room than is generally provided by the telephone type relay.

In addition, these features make the power type relay more resistant to rough handling when being installed, wired or serviced by relatively unskilled personnel. Unskilled or careless electrical workers cannot properly install, service or repair a telephone type relay, but may satisfactorily perform these services on a power type relay. This hazard cannot be ignored by the designer and user when selecting a relay to be installed and operated beyond control of the manufacturer.

Physical factors that favor telephone type relays are smallness and lightness. They are available in many sizes. Two miniature relays are shown in Fig. 4. There is, however, a minimum economical size. The spool size, obviously, must be such that it can be readily wound for the coil. The contact spring must be large enough to permit welding contacts to it. The minimum allowable size is dictated by the contact load to be handled by the contact springs, the number of contact springs required, the time delays necessary in speed of operation and release, and the amount of power available for relay operation.

When a circuit employs several relays, the advantage of mounting them side by side on a small surface or in a small inclosure is important. With smallness in size comes the advantage of reduced weight. In a small machine or a portable one, the weight aspect should be carefully considered. On large control panels mounting a number of relays, the use of a small relay may be a factor in meeting maximum floor loading requirements.

Power type relays often are limited to one, or at the most two, mounting planes. Telephone type relays are generally independent of mounting position restrictions.

Telephone type relays are engineered to meet the needs of the particular application. As many springs can be provided as required; they can be arranged in any form, order, combination, or group of combinations in any sequence as required by the circuit. This flexibility in arrangement combined with desired coil characteristics, enables the manufacturer to provide economically a relay "custom tailored" to each specific application.

Features providing maximum mechanical life and resistance to shock and vibration are not exclusive to telephone type relays, but seem to be more easily and economically provided on them. A telephone type relay with such inherent features is shown in Fig. 5.

Electrical Considerations

Electrical considerations that influence the choice of one or the other type of relay are dictated by the requirements of the application. For example, if the contact ' ·d exceeds the

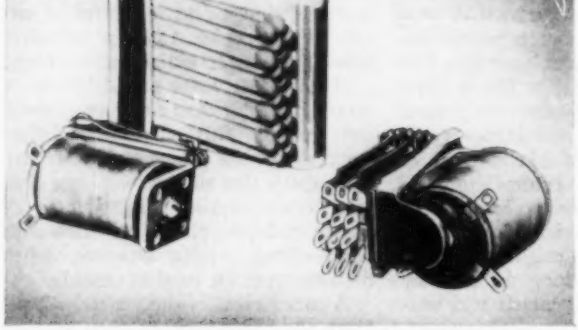


Fig. 4—Single and double arm pile-up miniature telephone type relays. Minimum size depends on physical and operating factors.

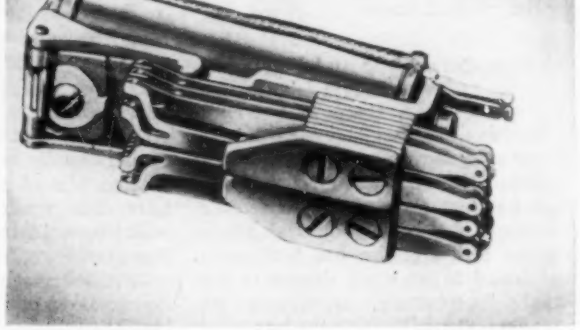


Fig. 5—Telephone type relay designed for heavy duty service, resistance to shock and vibration, and maximum mechanical life.

apabilities of the telephone type relay, hen the power type relay must be elected. On the other hand, a telephone type is required where a relay must follow impulses at a rate of ten o fifteen pulses per second.

To dissipate rapidly as much heat as possible, power type contacts are large. Their mating surfaces are large in area to keep the current density to a practical value. Such contacts, therefore, do not represent the ultimate in reliability in low-potential, low current circuits. Telephone type relay contacts, however, being smaller and consequently subjected to greater pressure per unit of area, provide a more reliable circuit where the potential is insufficient to penetrate insulating films on contacts, or where the service is not sufficient to keep the contacts cleaned. Conversely, where the power level controlled is high and voltage is sufficient to penetrate insulating films, the power type relay contacts may have an advantage.

Power type relays, which are long stroke devices, require more time for closing and opening their contacts than do the relatively short stroke telephone type relays. In addition, since they are generally more massive, power type relays are slower because of their greater inertia. With telephone type relays, however, time delays can be either produced or avoided as desired.

Economic Considerations

Despite the greater volume of material in power type relays, it is difficult to say that one relay is more or less economical than the other on this basis alone. Frequently, however, because of the greater number of springs and contact forms that can be accommodated along with timing features, one telephone type relay could be substituted for two or more power type relays at the same point in a circuit.

Selection of type of relay should be made on the basis of the degree of reliability desired rather than the cost. A relay that is selected on a first cost basis, but which is so unsuited to the application that charges for service calls have to be paid is obviously an unwise choice. A high quality relay although somewhat more expensive initially, therefore, may be a favorable economic choice.

Designers should consider relays as an integral part of their products, rather than things to be added after all other parts of the design have been completed. The ideal way to select a relay, based on economic and other principles, is to consider what the end result is to be, and work backwards to the "input."

This principle may be applied to the circuit shown in Fig. 3. Assume that the end result controlled is "a well designed electric motor," operating on 230 volts and having an inrush current of 15 amp. A power type relay having contacts capable of handling this load is obviously required, but the powering of such a relay without straining its contacts at "input" is impractical. Perhaps electronic tube amplification of power available from the control contacts is required; or a telephone type intermediate relay must be provided.

If this problem is attacked from the "input" end, the natural temptation is to use the telephone type relay indicated by the delicate nature of the control contacts, and try to get by without the power type relay. Such a solution would overload the contacts of the telephone relay and produce something less than optimum performance.

Unless fundamental limiting and economic factors are understood it is somewhat confusing to attempt the selection of the most suitable telephone type relay for any particular purpose. Different types result in varying degrees of performance in respect to life, economy, contact loading, size, weight, timing, and resistance to shock, vibration, temperature, humidity and corrosion.

A release time, for example, of 500 milli-seconds is readily obtainable under favorable conditions for the relay of Fig. 6. But a maximum release time of one-fifth this value is about all that can be safely obtained from a similar condition when the necessarily smaller copper slug volume provided by the relay of Fig. 4 is employed.

Similarly, since the contact pressures and resultant armature loading of miniature relays are usually about equal to that of the larger types, but nearly all bearing and wearing surfaces are necessarily reduced in size, it is unreasonable to expect a maximum life for the small relays of the same order readily obtainable from the larger types. The miniature relay of Fig. 4 will show as much mechanical wear and require as much readjustment after 50 million operations as the larger relay of Fig. 6 requires after 250 million operations.

Sometimes two relay types of approximately the same size and appearance have widely varying characteristics. The relay of Fig. 5, for example, is no larger than the relay of Fig. 7. Actually the relays of Figs. 5 and 6 mount on closer spaced mounting centers than does the relay of Fig. 7, because the springs do not extend outside the width of the heelpiece. Because of certain improvements in design, however, a life of from 2 to 10 times that of the relay of Fig. 7 is provided by the Fig. 5 relay.

It is interesting to note that whereas the relays of Figs. 5 and 6 need no lubrication in service because their bearings are grease retaining, lubricated at the factory, the relay of Fig. 7 does need field lubrication when service exceeds about a million operations per year, if maximum life is to be had.

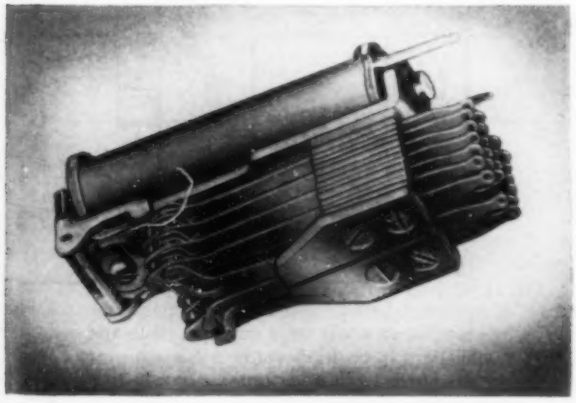


Fig. 6—A telephone type relay having a 1 to 1 lever armature ratio to obtain a slow release. Bearings are grease retaining.

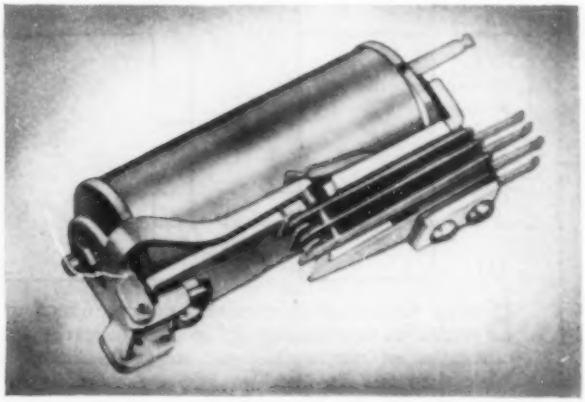
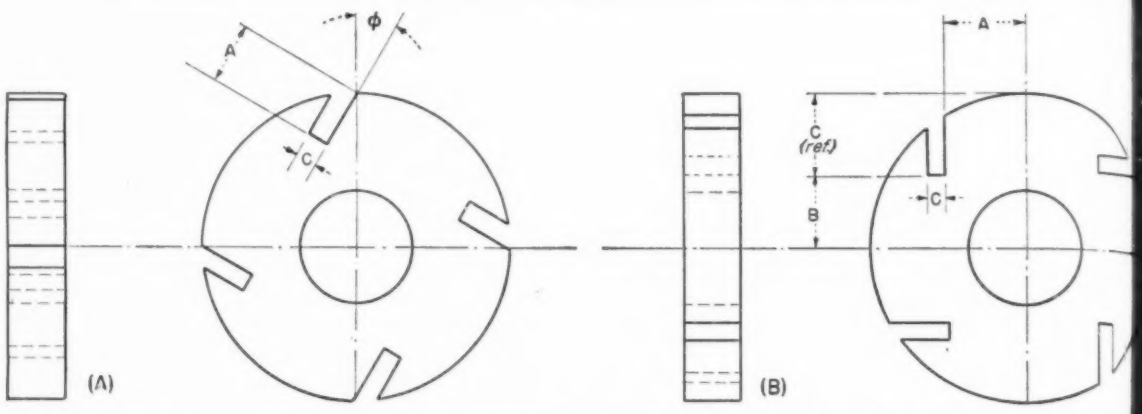
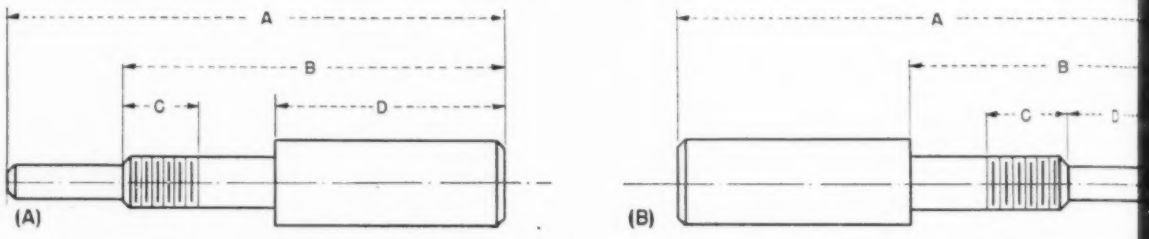


Fig. 7—A relay in which the springs extend outside the width of the heelpiece, thus increasing space required for mounting.

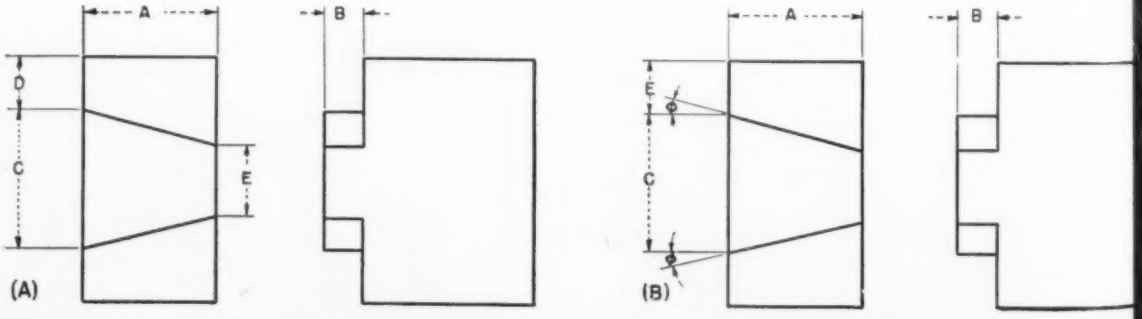
Dimensioning Parts fo



1 (A) According to accepted practice, the position of each slot is completely defined by the two linear and one angular dimensions shown. But this form makes it difficult to lay out the part for production on standard equipment because the exact position for the milling cutter is not known. (B) By rotating the part and defini the distance *A* from the center line, the milling ca can be immediately positioned. Reference dimension which varies with the tolerance of the blank diame is added to preclude shop miscalculations.



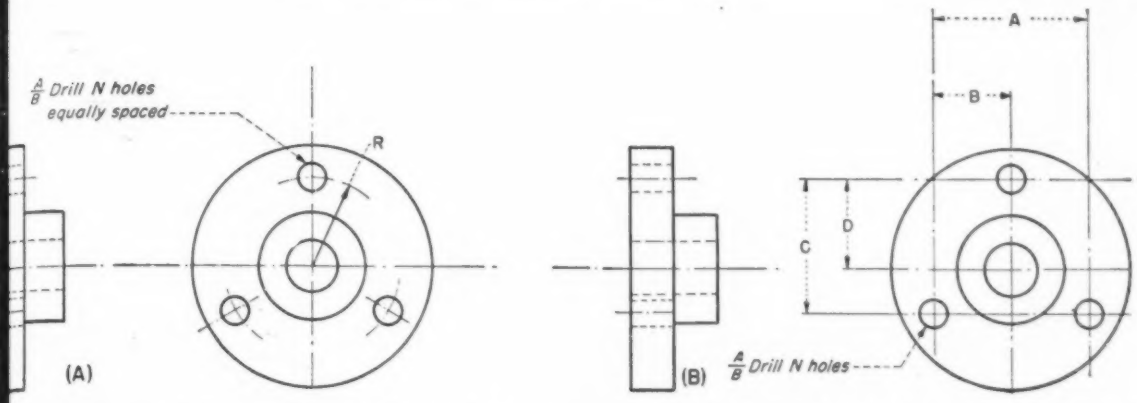
3 (A) A shaft dimensioned in this manner can be turned directly using the data given. However, shop calculations must be made to locate the shoulders so that carriage stops can be properly positioned. Furthermore, it is impractical to scale the given dimensions while the lathe is running. (B) Lathe operations are simplifi when the dimensions appear as above and carriage st can be set immediately. It is convenient to hold a cu against a shoulder during a turn and then disengage t carriage when *C* and *D* cuts are completed.



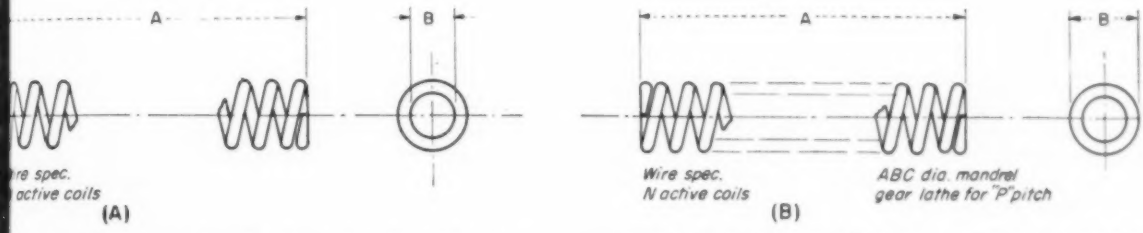
5 (A) Layout of this block as dimensioned requires trial-and-error location of reference marks or shop-calculation of the angle shown in (B). Either method takes time and can lead to errors that result in costly scrap losses. (B) If the angle ϕ is on the drawing when it is received in the production department, the block c be clamped in a vise on a machine table and swung arou to the correct position ready for machining. Shop erro are therefore less apt to occur, as well as appreciable ti and material saved.

Economical Production

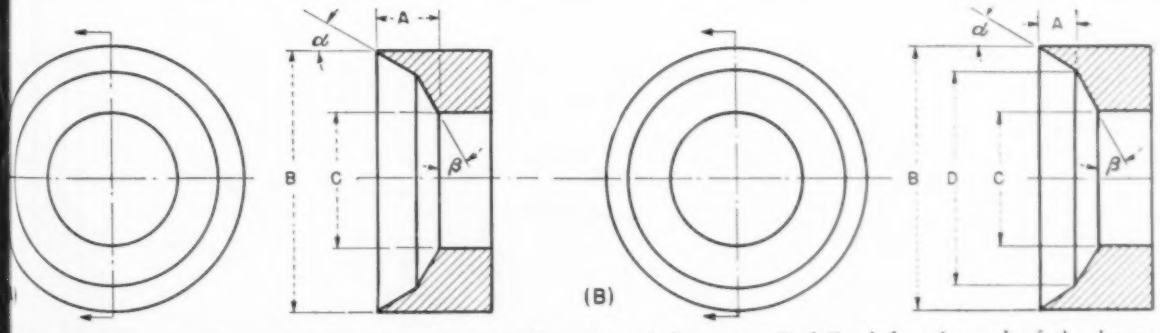
THOMAS L. LANE



(A) The center hole complicates the layout of flange holes, a dividing head or rotary table being required. specifying the radius *R* for the small holes, the error sed by tolerances is doubled when there is an even num- of flange holes. (B) This revision of dimensions permits the direct use of a height gage. If the small holes are drilled on a jig borer, the machine can be easily set up from the information as given because the dimensions are already in the required form, thereby reducing errors and saving costly setup time.



(A) When a spring is dimensioned as above, the mandrel size, as well as winding lead, is determined trial and error. This condition results because the ring becomes larger in diameter and coarser in pitch en the wire is relaxed after winding. (B) Handbooks contain tables that list mandrel sizes and winding pitches for a given wire size. Handbook data should be put on the drawing and the spring dimensioned to show the outside diameter. Setup time is thus reduced and checking of the diameter between parallels is simple.



(A) Though the shape of this part is geometrically determined, the intersection between the two tapers is t fully defined in terms of shop procedures. Without e use of algebraic computations, the length of cut is known. (B) The change in dimension *A* and the addition of dimension *D* fully define the end of the larger taper cut and the start of the smaller cut. No knowledge of algebra is required so that this source of costly shop errors disappears completely. Shop procedure is thus simplified and scrap reduced.

W. B. GIBSON
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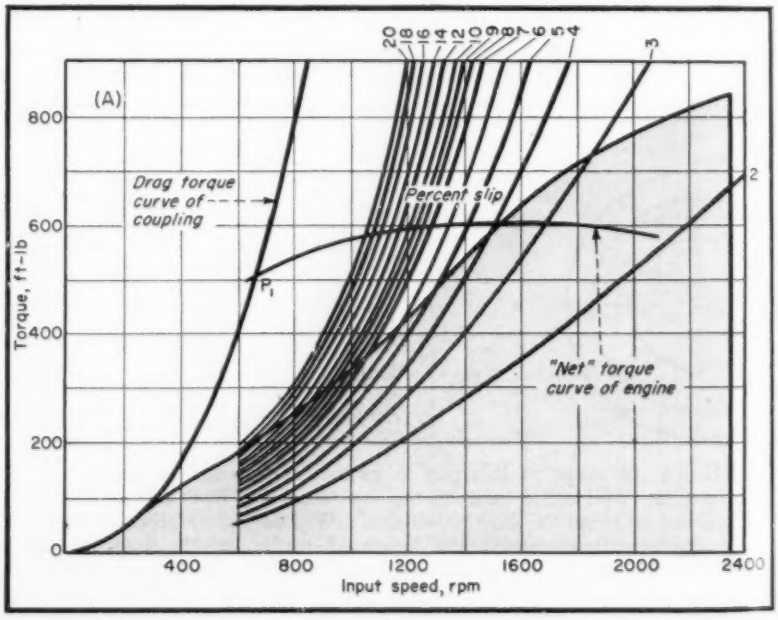
Selecting the Right FLUID COUPLING *For a Prime Mover*

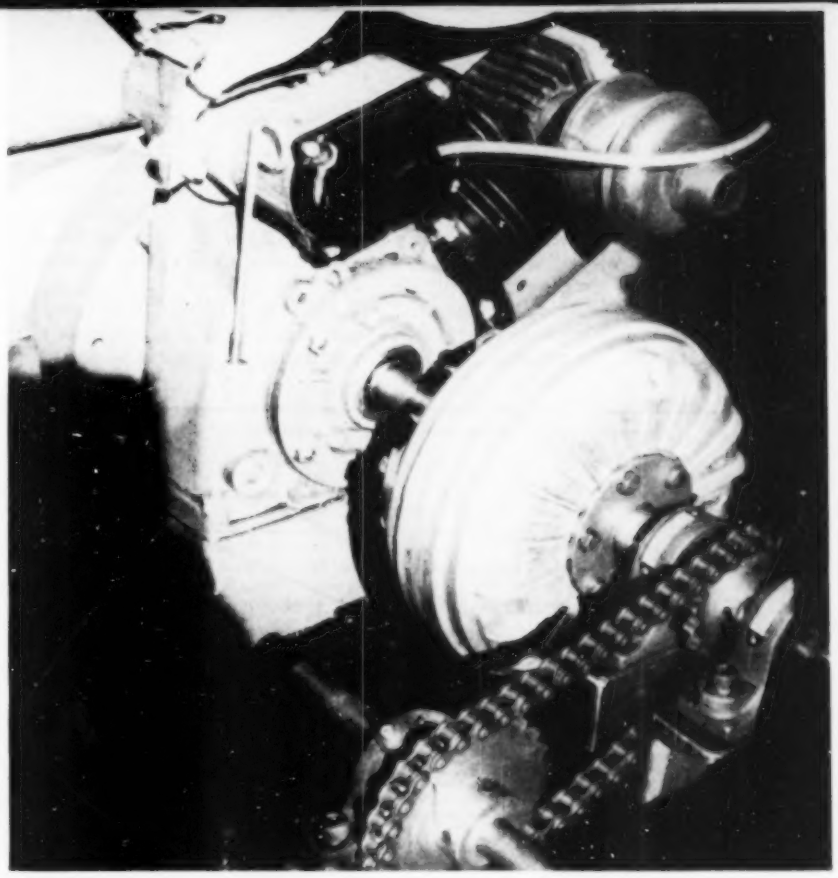
How to match coupling characteristics with performance characteristics of electric motors and internal combustion engines.

BY FAR THE MAJORITY of hydraulic couplings are used between internal combustion engines or electric motors and some piece of driven equipment. In choosing a coupling for a particular application, several factors must be considered. Once the performance characteristics of the prime mover are known, the "net" horsepower and rpm available to the coupling must be determined. Then, the proper size coupling must be chosen and the combined performance of the two units calculated by plotting the prime-mover torque-speed curve on the slip curve of the coupling selected. Finally, the heat-rejection capacity of the coupling must be checked for existing duty-cycle conditions.

When applying a hydraulic coupling to a power source, the size of the coupling is normally selected to give from 3 to 5 percent slip at full running load and speed. However, a compromise in the normal method of selection may be required to properly match the drag torque of the coupling with the torque curve of the prime mover. To make available the maximum engine or electric motor torque for starting and accelerating the load, it is desirable to have the drag torque curve of the hydraulic coupling intersect the prime mover torque curve at its peak output. This is especially true of standard squirrel cage electric motors where anywhere from 200 to 300 percent of the full load torque can be made available for accelerating purposes. When the armature comes up to the peak torque speed rapidly, the current consumption falls extremely rapidly from the initial starting current, which makes the motor starting problem much more simple, lessens motor heating and reduces power demand. To properly match the drag torque curve with the peak prime mover torque curve, may require the use of a smaller coupling or one of reduced capacity and thereby force operation at a higher rate of slip at the full load speed range. Inasmuch as slip is directly proportional to efficiency loss and therefore heating of the hydraulic coupling, good judgment must be used, taking into account the complete duty cycle of the machine on which the prime mover and hydraulic coupling is to be mounted, its location and operating conditions.

A thorough understanding of the slip curve of a coupling is imperative when selecting a unit for a given application. The capacity of a coupling at 2 percent slip is determined by establishing various input speeds and controlling the corresponding output speeds to exactly 98 percent and measuring the torque absorbed and transmitted. This process is repeated for 3, 4, 5.....percent to develop a slip curve as below in Fig. 1 (A), which is for a 17.5-in. stamped steel





SMALL TRACTION COUPLING on the output shaft of a 6 hp gasoline engine. Matching the coupling to the engine insures efficient operation.

hydraulic coupling without blade blocks (which are used to block off segments of the coupling and thus reduce its capacity).

Inasmuch as the coupling transmits the input torque to the output shaft without loss, performance of the prime mover and coupling combination can be calculated by plotting the prime mover torque speed curve on the slip curve. At each intersection of the prime mover torque curve with a slip curve, the output speed is determined by multiplying the corresponding input speed by the efficiency or 100 percent minus the slip. For example, assume the prime mover or input torque to be 700 lb-ft at 1,600 rpm. This occurs at 4 percent slip, and, therefore, the output will be 700 lb-ft at 1,536 rpm (1,600 x 0.96).

To apply a typical 17.5-in. hydraulic coupling to an internal combustion engine, "net" torque and horsepower curves of the latter must be considered. The "net" curve represents the power and torque available at the flywheel after deducting all parasite loads such as fan, generator and other accessories. The "net" torque curve of this engine is therefore plotted on the slip curve as shown in Fig. 1(A). It will be noted that the drag torque curve of the hydraulic coupling intersects the engine torque curve at an input speed of 660 rpm, well below the peak torque available from the engine. Under these conditions, the coupling is "lugging" the engine. The unmodified 17.5-in. coupling is therefore too large for this engine.

The capacity of the coupling can be reduced by installing blade blocks to reduce the volume of oil pumped. Looking at Fig. 1(B), which represents the same 17.5-in. coupling, but with blade blocks installed, the "net" torque curve of the typical engine is again plotted on the slip curve. Now the output shaft stalls at an input speed of 895 rpm, which is much closer to the peak torque of the engine.

At full throttle the engine will deliver 580 lb-ft torque to the coupling at 2,100 rpm, while the hydraulic coupling will deliver 580 lb-ft torque to the driven equipment at 2,037 rpm, a 3 percent loss in rpm or efficiency. Since the hydraulic coupling will permit delivery of 560 lb-ft torque to the driven equipment at zero rpm, there is, theoretically, an increase in the speed range some 800 to 900 rpm because a force can be applied to the load to complete stall without "killing" the engine. This range, however, is limited to extremely short periods, mainly because the coupling becomes overheated. It is, therefore, more of a

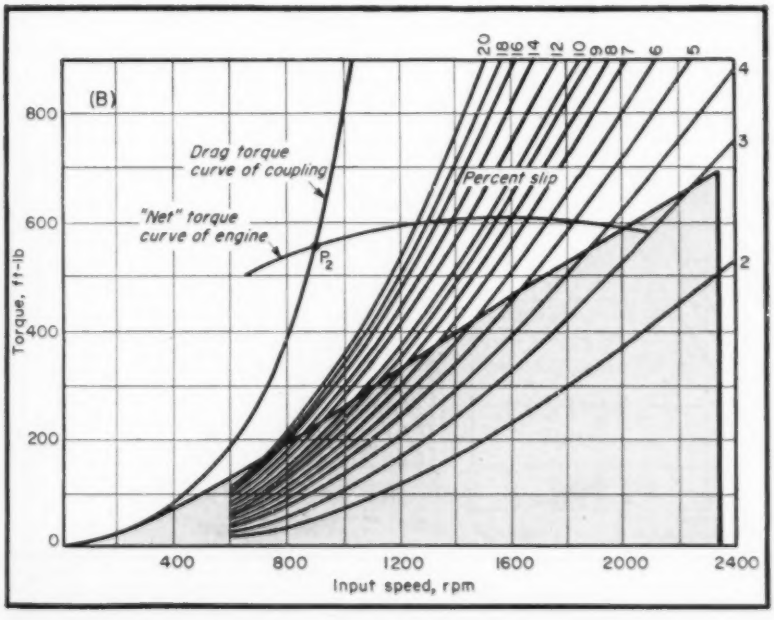


Fig 1—Performance characteristics of 17.5-in. stamped steel hydraulic coupling. Drag torque and family of slip curves are plotted for unmodified coupling without blade blocks, (A), and modified unit with blade blocks (B). "Net" torque curve for internal combustion engine intersects drag torque curves at points P_1 and P_2. P_1 at input speed of 660 rpm, shows operation is well below the peak torque of the engine and indicates coupling is too large. P_2 at input speed of 895 rpm, is closer to peak engine torque.

safety feature to prevent stalling the engine, provides more time to release the master or service clutch and reduces the shock imparted by the engine flywheel. Cooling may be provided in certain models of hydraulic couplings by an air to oil radiator or an oil to water heat exchanger to permit long periods of running at high slip.

The unshaded areas in Fig. 1 represent the safe, continuous operating range in which maximum torque and speed can be obtained without overheating the coupling. For example, the typical internal combustion engine may operate at full throttle and approximately 3.6 percent slip continuously without over heating. Four percent slip would be marginal and 5 percent slip definitely questionable. Continuous operation at higher slip would result in overheating in a relatively short time. Short periods of high slip for starting or accelerating loads with adequate periods of normal slip operation for cooling are not at all detrimental.

Partial throttle operation may well permit continuous high slip without overheating, such as 14 percent slip at 200 lb-ft torque and 815 rpm input. Similarly, continuous stall at 300 to 400 rpm input is permissible, as might be obtained on a hoist with drum brakes set and master clutch engaged.

If accurate heat rejection data are required, reference should be made to the heat rejection capacity curve, Fig. 2. Heat rejection capacity is based upon stabilization of coupling temperature at 150 F above free air or ambient temperature and is related to input horsepower.

Use of the heat rejection curve is simple in that the operating condition for a given coupling is determined with respect to input torque, input rpm and slip. Input horsepower is determined from input torque and rpm and then, by use of the slip figure, the heat rejection required is calculated in terms of horsepower. Referring to Fig. 1(b) for full throttle operation, assume a condition in which there is 4½ percent slip at 1,900 rpm input. This represents 600 lb-ft torque or an input of 217 hp. Heat loss at 4½ percent will be 9.77 hp. Referring to Fig. 2

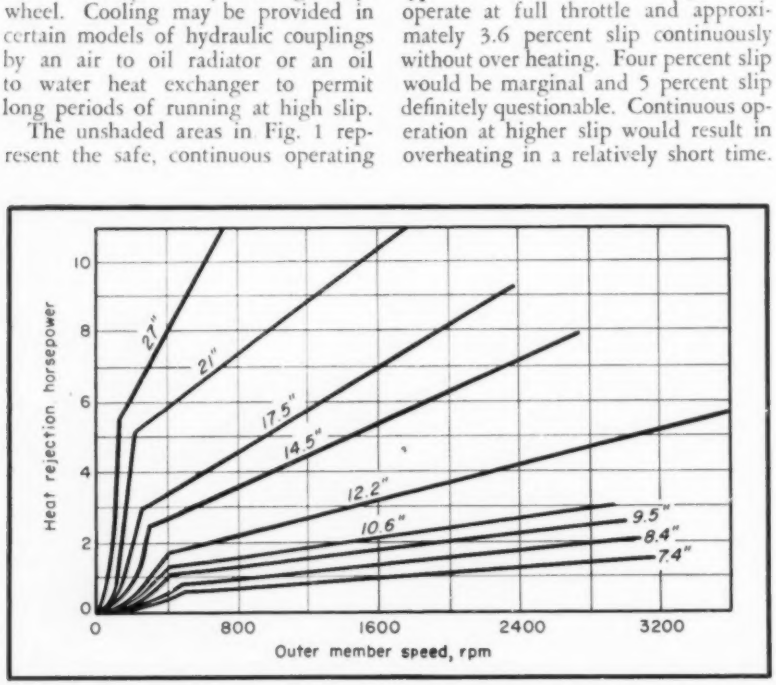


Fig. 2—Heat rejection capacity chart for fluid couplings plotted in terms of horsepower at 150 F rise above ambient temperature. Values taken in free air have been reduced by one-third to allow for housing, insulation and paint, which restrict escape of heat.

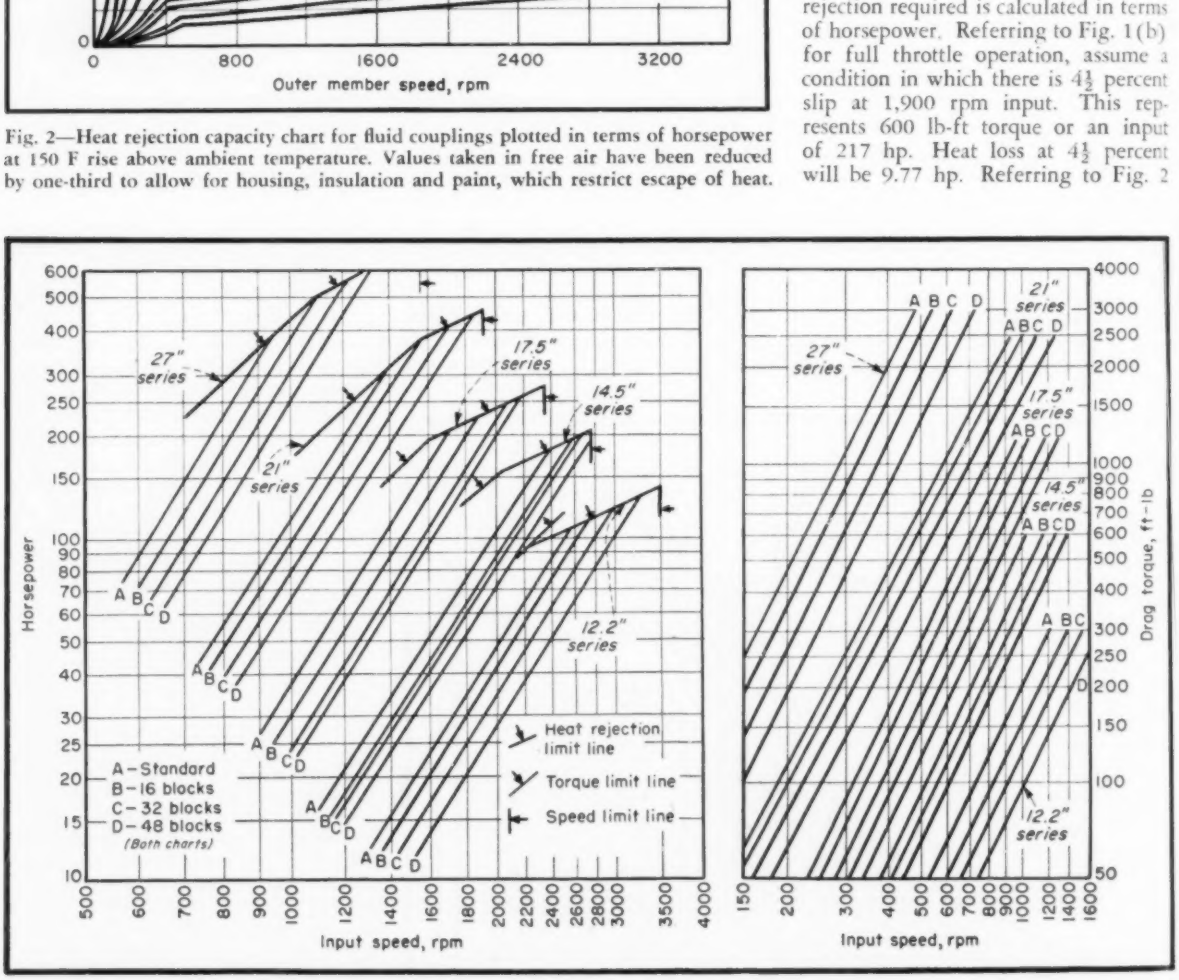


Fig. 3—Horsepower capacity and drag torque charts for steel couplings ranging in size from 12.2 through 27 inches. *B, C* and *D* curves on both charts are for basic couplings that have been modified with blade blocks to reduce unit capacities.

for the 17.5-in. coupling at 1,900 rpm input, the heat rejection capacity is 7.9 hp, which is a little short of the 9.77 hp required. If the coupling is to be shrouded or may possibly be painted frequently, the condition should not be approved. If the unit is to have ample circulation of air and is not otherwise insulated, the condition is satisfactory.

One important factor regarding heat rejection capacity of traction couplings is that the larger the coupling, the lesser the continuous slip permissible. Heat rejection capacity is mainly a function of the surface area exposed to the air and therefore is directly related to the diameter of the coupling, whereas the horsepower (and torque) capacity is related to the fifth power of the diameter. While a 7.4-in., single-circuit aluminum coupling can operate continuously at 20 percent slip at 1,750 rpm input, a 27-in. unit must be held within 2.6 percent continuous slip at 1,300 rpm input. Although the 27-in. coupling is only 5.75 times larger than the 7.4-in. unit, hp capacity is more than 600 times greater.

To facilitate the selection of the proper hydraulic coupling to match a given input horsepower and speed, the "Horsepower Capacity Chart" shown in Fig. 3 has been devised for typical steel couplings ranging in size from 12.2 in. through 27 in., and a similar chart, Fig. 4, for aluminum couplings from a 7.4-in. single-circuit unit through a 10.6 in. size. In both cases, two graphs are shown—first the "Horsepower Capacity" and second, the "Drag Torque". The first shows the horsepower capacity of various size couplings at rated full load slip of 3 percent for the steel couplings and 4 percent for the aluminum couplings. Because the capacities shown are for the couplings, the "net" horsepower of the prime mover after all parasite loads have been deducted must be used. An engine rated 60 hp at 2,100 rpm would require a 12.2-in. coupling without blade blocks. However, the manufacturer's curve states this to be for the bare engine. Investigation, in this instance, shows the parasite load for fan, generator and other acessories to be 10 hp, leaving a "net hp" of 50. Therefore a 12.2-in. coupling with 16 blade blocks is necessary.

Speed of the prime mover will affect coupling selection. Had the prime mover been an electric motor rated 50 hp at 1,750 rpm, a 14.5-in. coupling with 48 blade blocks would be suitable. In the event the electric motor had an operating speed of 1,150 rpm, then a 17.5-in. coupling with 16 blade blocks would be used.

Fluid Coupling Terminology

FLUID COUPLING—A device for transmitting power by means of the kinetic energy of high velocity oil circulating within a closed fluid circuit.

TRACTION COUPLING—A fluid or hydraulic coupling where the oil circuit is completely sealed, with no provision for cooling, variable fill, or disconnecting.

VARIABLE FILL COUPLING—A hydraulic coupling equipped with an oil sump and means for varying the volume of oil within the hydraulic coupling circuit to obtain variable speed on the output shaft with constant input speed. Cooling is usually required.

DISCONNECTING COUPLING—A hydraulic coupling equipped with a sump and a device for completely emptying the hydraulic circuit of the coupling or filling the same permitting a complete disconnect of power transmitted. Cooling may or may not be required for this type of hydraulic coupling.

IMPELLER—Generally referred to as the input side of a hydraulic coupling.

RUNNER—The driven portion of the hydraulic coupling.

SLIP—Slip refers to the speed loss on the output shaft as related to the input shaft and is expressed in terms of percent of the input speed. The percentage of slip is directly proportional to the efficiency loss.

DRAG TORQUE—The torque absorbed by the hydraulic coupling at various input speeds, but with the output shaft completely stalled. Inasmuch as the coupling transmits torque without loss, this represents both the load imposed upon the prime mover at various input speeds as well as the torque transmitting capacity of the coupling at stall.

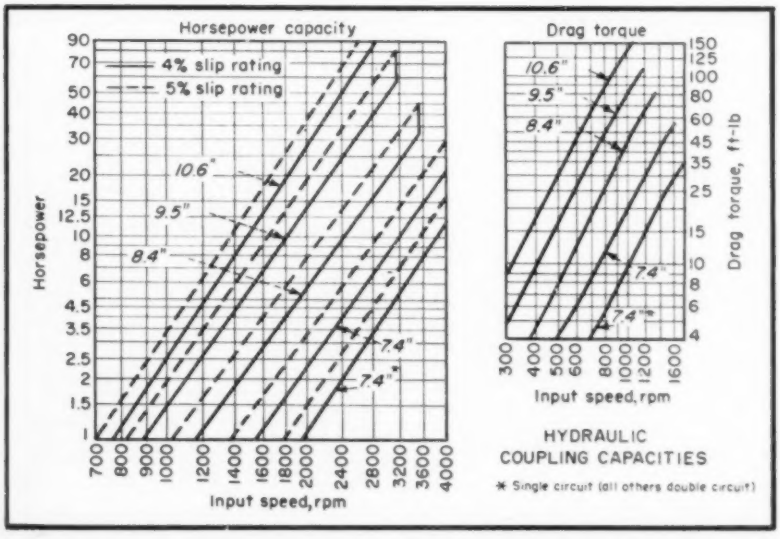


Fig. 4—Horsepower capacity and drag torque charts for single-circuit aluminum couplings ranging in size from 7.4 through 10.6 inches.

Application to Driven Equipment

In applying a prime mover-coupling "package" to driven equipment, complete data regarding the "work" or "duty" cycle of the latter must be known. Caution should be taken to insure against stalling at critical points during the cycle. Here, a stall does not necessarily cause permanent damage to the engine, but, in the case of an electric motor, this condition leads to burned out windings. Knowledge of the duty cycle is therefore a "must".

Most of the problems faced when adapting the "electric motor-coupling package" to driven equipment can be illustrated by considering its application to a centrifuge.

In general, centrifuges require little horsepower after reaching full speed, and for this reason, it is important that the true running horsepower be determined by actual measurement whenever possible. Other than this, it is desirable to know the time required to accelerate the centrifuge and the temperature rise of the coupling in bringing the centrifuge up to speed. This information also simplifies the determination of the number of starts, reversals or "plugs" per hour that are permissible.

Consider a centrifuge 54 in. in diameter that must be accelerated to 750 rpm. The WR^2 factor is estimated to be 8,300 lb-ft^2. The duty cycle requires 2.0 min to unload and load, 3.0 min centrifuge-time at full speed and 1.5 min to brake with air (no load on motor-coupling). An average of six cycles must be completed every

hour. The motor and coupling size, time to accelerate, temperature rise for one start and number of starts per hour without overheating must be found.

A 15 hp, 1,800 rpm, high starting torque motor is being used with a "V" belt reduction drive to the centrifuge. Actual readings indicate that a 10 hp, 1,800 rpm motor might be used with a fluid coupling.

Reference to the horsepower capacity chart, Fig 4 shows a 9.5-in. aluminum coupling is suitable for 10 hp at 1,750 rpm with about 4.5 percent slip. The actual torque-speed curve for the motor is plotted on the 9.5-in. coupling slip curve as in Fig. 5 and a table prepared in which to record several values of motor-speed, torque and slip for computing the output characteristics. Points on the motor-coupling slip curve are determined from the shape of the curve, in this case for stall, 20, 15 and 10 percent slip as well as full load at 4.5 percent slip. These values are then averaged since, for simplicity, constant or uniform torque can be assumed during acceleration. By breaking down the problem into small increments of input rpm, solving for each and summarizing final results, more accurate checks can be made.

The ratio required between the coupling and centrifuge is the coupling output rpm at full load, 1,660 rpm, divided by the centrifuge rpm of 750 or 2.21 to 1.0. Using the average value for the torque, 58.1 ft-lb times 2.21 becomes 128.5 ft-lb at the centrifuge. Substituting in the accelerating time formula in which

WR^2 = WR^2 factor of centrifuge, lb-ft^2
N = Centrifuge speed, rpm
T = Aver. torque, lb-ft
t = Acceleration time, sec

$$t = \frac{WR^2\ N}{308\ T} = \frac{8300 \times 750}{308 \times 128.5}$$

$$= 157 \text{ sec or } 2.62 \text{ min}$$

This gives a cycle time of

Unload and load	2.00
Accelerate	2.62
Centrifuge	3.00
Brake	1.50
Total time per cycle, min (6.58 cycles per hour)	9.12

In computing the temperature rise per start and determining whether or not the coupling can handle the entire duty cycle without overheating, the "lost" horsepower values (due to slip) must be used to determine the heat absorbed; and the heat rejection curve from Fig. 2 used to determine the heat rejected to the air. A balance for the entire cycle must be obtained in favor of the heat rejected if operation is to be continuous without overheating.

A balance can be determined by taking each phase of the cycle individually. During the accelerating period, there is an average horsepower loss of 3.95 in 157 sec. During this period, the average *output* rpm is 1,074. At this rpm, the actual heat rejected is equivalent to 1.46 hp (according to Fig. 2) for the same period of 157 seconds.

Similarly, during the centrifuge phase, there is 0.45 hp lost during 180 sec., but an equivalent of 1.8 hp in heat rejected to the air for 180 sec. Here the *output* rpm of 1,660 is used.

During the braking period, the motor is shut-off, but the coupling, being connected to the tub, will tend to brake the motor. It is reasonable to assume the same conditions as for the centrifuging phase during the 1.5 min or 90 sec of braking time. Therefore, 0.45 hp in heat is generated for 90 sec and an equivalent of 1.8 hp in heat is rejected to the air during the same period. No cooling can be expected during the stationary (loading and unloading) phase because there is no effective circulation of air.

Using the constant value 0.708 btu/hp/sec to figure the amounts of heat absorbed and rejected during the different phases of the duty cycle, and summarizing using the above horsepower and time intervals:

Heat Absorbed		
Accelerating	$0.708 \times 3.95 \times 157$	= 439.0
Centrifuge	$0.708 \times 0.45 \times 180$	= 57.3
Braking	$0.708 \times 0.45 \times 90$	= 28.6
	Total btu	= 524.9

Heat Rejected		
Accelerating	$0.708 \times 1.46 \times 157$	= 162.2
Centrifuge	$0.708 \times 1.80 \times 180$	= 229.2
Braking	$0.708 \times 1.80 \times 90$	= 114.6
	Total btu	= 506.0

The 18.9 btu of heat not rejected is of no major concern because the heat rejection capacity curve, Fig. 2, allows for a safety margin of 50 percent. Since 18.9 btu represent only 3.74 percent of the 506 btu rejected, there will be no overheating, providing there is reasonable free cooling air available and no insulation around the coupling.

To determine the actual temperature rise during the accelerating phase, the net heat absorbed during this period must be used. The empty 9.5 in. coupling weighs 16.8 lb and the specific heat of aluminum is 0.214; while the 0.86 gal of oil in the coupling weighs 5.95 lb (one gallon weighing 6.92 lb and having a specific heat of 0.5). Substituting in the temperature formula in which

B_a = btu absorbed
B_r = btu rejected
W_c = weight of coupling, lb
W_o = weight of oil, lb
S_a = specific heat of aluminum
S_o = specific heat of oil
T_R = temperature rise per start, deg F

$$T_R = \frac{B_a - B_r}{(W_c \times S_a) + (W_o \times S_o)}$$

$$= \frac{439 - 162.2}{(16.8 \times 0.214) + (5.95 \times 0.5)}$$

$$= 42 \text{ deg F}$$

Further, since the average motor speed during the accelerating period is 1,397 rpm, the motor can be safely operated during the above cycle without overheating.

Straight line accelerations, such as those that occur in belt conveyors and hoists having rotating masses moving at different speeds, must be resolved to the speed of a common shaft, usually the prime mover shaft. However, with hydraulic drives the resolution should be to output shaft of hydraulic unit.

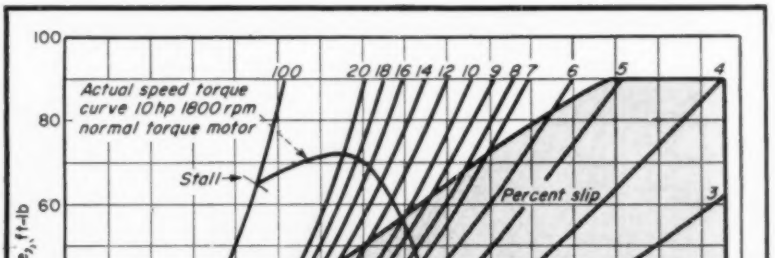


Fig. 5—Performance characteristics of 9.5-in. aluminum coupling with torque-speed curve for 10 hp, 1,800 rpm normal torque motor plotted on coupling slip curve.

Fig. 1—Severe condition of bearing races due to friction oxidation. This phenomena of large indentations has often been called "false brinelling." Such a condition is not the result of deformation from extremely heavy loads but due to wear caused by the small oscillating motion of balls which prevent adequate surface lubrication.

Factors When Considering

Anti-Friction Bearings

For Oscillating Service

Modified load rating and recommended lubrication practices will minimize premature damage and failure when these bearings are subjected to small oscillations.

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LOAD RATINGS of anti-friction bearings that oscillate through small angles must be lower than those of a single-direction rotation bearing. The method of installation and the lubricant to be specified also requires special consideration. Otherwise, premature bearing failures will be the result. Initial conditions of such failures have been called false brinelling, fretting corrosion, or friction oxidation.

When bearings fail under oscillating loads, the races show signs of deformation and discoloration in the region of ball contact. This condition is shown in Fig. 1. In addition, the balls or rollers have slight flats in the area of contact. Such failures have been observed in a wide variety of applications.

Years ago this type of failure was observed in automobiles which were shipped in freight cars across the country. Even slight oscillations of the front wheels under the light load of their own weight produced similar results: balls and rollers were found to be embedded in the races. These bearings would fail completely after driving short distances. Main thrust bearings of variable-pitch airplane propellers and helicopter rotors also have failed in the same manner, as did control pulley bearings and textile machine bearings which were subjected to oscillatory motion of small amplitudes. There are many applications of anti-friction bearings which are subjected to vibration while normally at rest of oscillate through small angles; automobile spring shackles and king pins, aircraft rocker arms, landing wheels, and cam followers are susceptible to this phenomena.

Bearing damage of this type has been considered as fretting oxidation that is caused by the simultaneous oxidation of the grease (which becomes acid), and the oxidation of the metal in the race. This action causes an appreciable amount of iron oxide to mix through the grease and form a lapping compound. This abrasive mixture inside the bearing speeds up the rate of deterioration. Frictional oxidation causes very short bearing life as compared with the normal fatigue failure life of single directional motion. In one application, where three to five years of uninterrupted (single rotation) service was common, the identical bearings with oscillating motion would disclose severe indentations through the bearing race within a period of 90 days.

To better understand this problem of oscillating motion, an intensive testing program was undertaken. A series of tests were conducted on bearings for three distinct and separate types of bearings: (1) thrust washers; (2) radially loaded deep-groove bearing; (3) thrust loaded shallow-race bearing. In addition, many different types of lubricants were used. From these tests, considerable data was accumulated which has given not only a better understanding of the problem, but also design factors which should

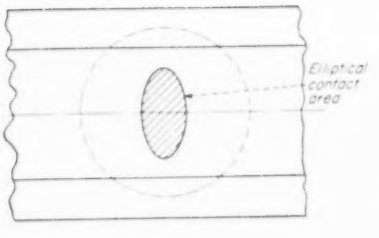

Fig. 2—Localized area of contact is the result of a load acting between the curved surfaces of the balls and races. The semi-elliptical stress distribution shown lies within the area of contact and can be calculated by the Hertz equation.

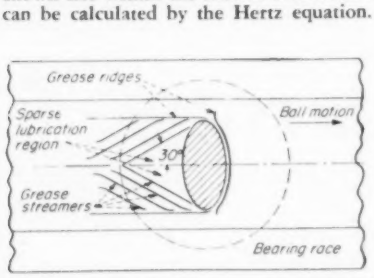

Fig. 3—Single-directional motion of ball in fluid greases cause a definite pattern. An oscillating movement results in contact of ball in the sparsely lubricated region.

mitigate the problem of oxidation.

With a ball under load in the bearing race, there is an area of contact (Fig. 2) which is dependent upon the load and the dimensions of the ball and race. As the ball rolls, this contact area moves around the bearing race and the volume of grease disturbed by ball motion follows a definite pattern. This is shown in Fig. 3. As the ball squeezes aside the grease, there will be heavy ridges of grease in front of the elliptical contact area; following the ball there will be streamers which are the result of the grease returning to fill the void caused by the passing ball. These streamers trail behind in a triangular shaped area which is devoid of grease; this condition is possible only with highly fluid greases which tend to follow in closely behind the contact pressure ellipse of the moving ball. Thus, with reciprocating motion this poorly lubricated area is subjected to cyclic loads. A more severe condition exists with heavier and fibrous types of grease; for a channel or path is formed by the oscillation motion of the ball and replenishment behind the ball does not occur due to the lack of trailing grease streamers. Although such greases have good adhesive qualities, the critically stressed surfaces are not lubricated.

Totalization of Pressure

The severity of the contact between improperly lubricated surfaces is measured in terms of a quantity known as the Totalization of Pressure. This totalization for any point is the total pressure passing over that point before that point is relubricated. The relubrication may come either from contact with the main body of the lubricant or to a lesser extent by contact with the lubricant in the form of a mist. The effects of lubrication and load conditions can best be illustrated by certain oscillating conditions which may exist.

USUAL OSCILLATORY CONDITIONS where the bearing race is subjected to two types of totalization. This is illustrated in Fig. 4(A) where the region in between the extreme points are relubricated before they again come in contact with the ball. Hence, this condition is similar to that of a single-rotation bearing. At the extremeties, however, the situation is different. Here the contact area passes partly over a point, changes its direction and passes back again over this point before this region can be relubricated. Totalization is therefore obtained by considering part of the contact area as passing over the point twice. Calculating the magnitude of totalization in this region gives a maximum of twice the value of that of uniform rotation. See Fig. 4(B).

EXTREME OSCILLATORY CONDITIONS where the most critical condition occurs when the length of motion decreases so that the ellipses of contact overlap. This overlapped position never moves enough to become relubricated. As a result, the totalization of pressure per lubrication cycle in this region becomes infinite (Fig. 5). Another extreme operating condition exists when the time of dwell is long (at reversal which occurs twice per lubrication cycle) and thus squeezes the lubricant film thinner than any single direction rolling could do. This action permits the two metals to approach each other sufficiently close that molecular attraction welds the metal and which breaks leaving jagged depths or pits.

Bearing Rating

Under oscillating conditions, the load rating of a bearing should be less than that under conditions of uniform rotation. On the basis of equal values of peak totalization, the load should be reduced to approximately 35 percent of that of a single-direction bearing operating at equivalent speeds. With this consideration, an oscillating bearing would have the same safety factor as single directional bearings. However, this relationship is not valid when the motion is small so that the contact ellipses of an individual ball overlap.

In choosing a bearing from a catalog, the equivalent or hypothetical speed of the oscillating bearing must be first determined on the basis of equal numbers of stress repetitions per minute caused by the individual balls moving at the retainer speed.

In choosing bearings, catalog ratings should be used as follows:

A 9114K bearing is radically loaded with 884 lbs. The inner race oscillates ± 38 deg at 450 cpm.

An extra-light bearing 9114K is considered for a 884 lb radial load application. It has a 70 mm bore, 110 mm OD and 15/32 in. balls.

There are 14 balls in this bearing, so the angle between the balls is 360/14 = 25.714 deg. Since the balls move 42 percent of the inner race movement, this motion is: 0.42 × 76 deg = 31.92 deg. This angle is greater than the ball spacing; thus a point on this race is

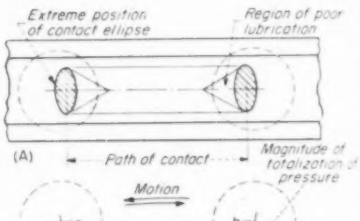

Fig. 4—Extreme positions of balls in oscillating motion have poorest lubrication and result in highest Totalization of Pressure. (A) Plan view illustrates region of poor lubrication. (B) calculated Totalization of Pressure, T in end zones is twice that of the center region; friction oxidation wear of Fig. 1 occurs here.

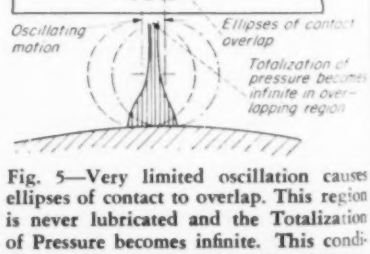

Fig. 5—Very limited oscillation causes ellipses of contact to overlap. This region is never lubricated and the Totalization of Pressure becomes infinite. This condition causes premature bearing failures.

ontacted by two adjacent balls during each cycle. Consequently, there are four loadings during each oscillating cycle (two loadings normally occur in each cycle when only one ball contacts a point on the race). The frequency of load application is: $4 \times 450 = 1{,}800$ loadings per minute.

This rate of loading is to be compared with that of a single direction motion where 42 percent of the balls pass a particular spot during each revolution of the inner race. In this case, $0.42 \times 14 = 5.88$ balls per revolution of the inner race. With this factor, the hypothetical speed of the oscillating bearing is: $1{,}800/5.88 = 306$. At this speed, the particular bearing has a radial load rating of 3,163 lb; for an oscillating load, the rating becomes $0.35 \times 3{,}163 = 1{,}107$ pounds.

If a bearing were chosen for this application with smaller balls, such as a KP 33B with 41 balls, only one ball would pass a particular spot on the race. As a result, the contact area would be loaded twice during each oscillation $\therefore 2 \times 450 = 900$ loadings per min. In addition, the single direction load frequency is $0.42 \times 41 = 17.22$ balls contact a point on the outer race for each inner race revolution. Thus the hypothetical speed is $900/17.22 = 52.3$ rpm. This value is to be compared with the speed of 306 rpm above.

If the outer race were the driving member, a factor of 60 percent should be used (instead of 42 percent) to determine the motion of the balls.

Ball Size: Whenever possible the oscillating motion should be made sufficiently large to insure optimum lubrication: where fresh lubricant is brought into the contact areas. Overlapping conditions of the contact areas of a single rolling element should be avoided, but overlapping of two or three adjacent rolling contacts is desirable. If the motion is extremely small, two steps can be taken: (1) the ball size should be reduced so as to approach 180 deg ball rotation; (2) the outer race should be made to oscillate with the inner race held stationary. Ball position will move approximately 60 percent of the outer race angular motion. With the inner race moving (outer stationary) the ball positions move about 42 percent.

In choosing an oscillating bearing the KPB series (aircraft type) should be useful. Since they have many balls, a smaller angle of the driving race will cause a point on the ball to contact both races.

Lubrication; The choice of a proper lubricant is an important part of this type of application. Most types of greases customarily used in single direction bearings have proven unsatisfactory for this purpose. There has been one exception, where a zinc oxide filled grease was very satisfactory. Extensive testing has revealed that certain greases can increase the performance of oscillating bearings by 30 times as compared to those previously used. The lubricant specified for oscillatory motion must be very fluid, and not prone to oxidize. Lithium-base greases and some fluid, extreme-pressure greases have proven most satisfactory.

There are two simple ways that oscillating bearings can be applied:

(1) Individual bearings having integral grease seals; this type should be *fully packed* before installation.

(2) Bearings assembled in a group and the outer seals are retained, requires external connectors for grease supply *under pressure.*

Besides these, special housings can be designed with certain considerations in mind: Provisions must be made for greater capacity of lubricant; good grease seals should be used to prevent the escape of lubricant, and thus reduce the amount of oxygen available; grease chamber must be fully packed and under pressure if possible to force the grease into the critical and sparsely lubricated zones. For example, in the testing program, removing one bearing seal was found to reduce the bearing life materially.

Bearing life can be increased by changing the lubricant periodically. The abrasive action of material worn off the bearing surfaces causes the major part of the damage associated with friction oxidation. In addition, the lubricant becomes more corrosive as its properties change through oscillatory lubricating action. Changing the lubricant not only removes the abrasive particles, but also supplies a less corrosive lubricant to the bearing.

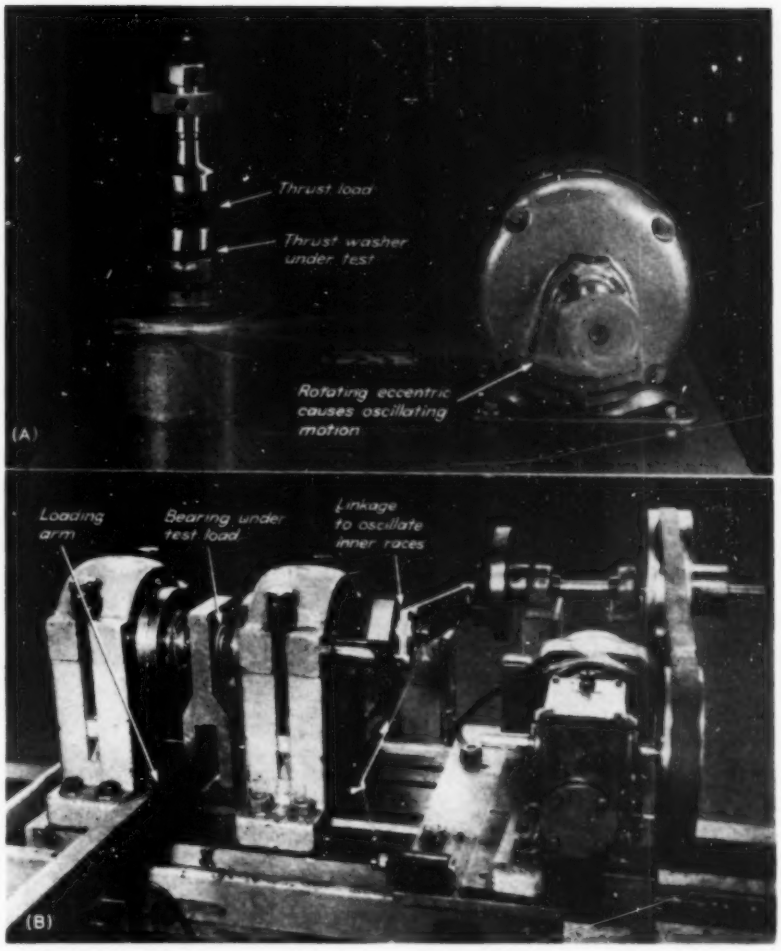

Fig. 6—Extensive testing on oscillating bearings has proven the Totalization Theory and established a basis for properly rating bearings for this type of application. (A) Machine used to test thrust washers. (B) Testing machine for radial loaded bearings.

12 Ideas

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SMALL PARTS, FASTENINGS, AND PACKAGE COMPONENTS are usually brought to processing and assembly operations in random heaps. Where these operations are to be mechanical, the parts must each be separated from their pile, oriented into the correct position, and fed in proper numbers and timing. Several firms manufacture ingeniously contrived hoppers applicable to many of these feeding, sorting, and counting operations, but except in the case of standard screws, nuts, washers, caps, and parts approximating them in shape, modification or a special design is usually necessary. Ten designs by the author are

Materials and Shapes	1	2	3	4	5	6	7	8	9	10	11	12
Round and Flat	X				X	X	X		X	X	X	X
Long Cylinders			X	X		X	X	X		X		
Cubes				X				X	X	X		X
Irregular Shapes		X		X		X						X
Symmetrical Parts having Projections			X	X		X	X	X	X			X
Spheres	X				X				X			X
Fragile or Brittle	X		X				X			X		X
Soft	X			X	X	X	X	X	X	X		X
Nesting or Tangling		X		X		X		X				
Delivery Rate over 100 parts per minute	X	X		X	X	X	X	X				X
Delivery Rate under 100 parts per minute			X				X		X	X	X	
Multiple Stream Delivery	X				X			X				X

Best Applications of Designs Illustrated: The selections noted above can only be a rough guide to designers. Where several mechanism could handle a given type the simplest designs have been noted; special considerations must be weighed in all cases.

1. Pierced Drum Feeding, Sorting, and Counting Hopper

A drum driven by a ring gear and supported on idler rolls has stationary troughs fitted into the ends which hold the supply of parts. One line of holes around the drum, closely spaced, will remove a stream of parts when they drop onto a slide at the exit point. A stationary external guard keep parts from falling through except at the discharge point, and an internal guard lining the upper half keeps parts not discharged from falling back. The drum is slightly thicker than the height of the part, a bearing cap in the illustration. The drum revolves slowly enough so the supply of parts does not tumble, but rides in the bottom. A pair of slides projecting far enough into the chute to pick up an upturned rim but clearing those turned down, will remove improperly oriented pieces. These may be dumped into a bucket at the end of the slides, or into a hopper equipped with a conveyor to return them to the feeding troughs. A counting roll fitted with spokes projecting up through slots in the delivery slide, will hold parts on the slide until needed. The slide will fill back to the drum, and

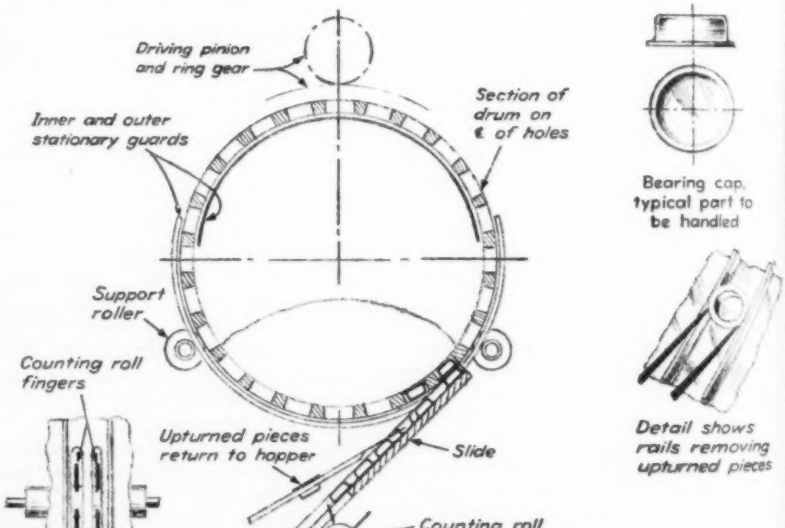

Driving pinion and ring gear
Section of drum on ℄ of holes
Inner and outer stationary guards
Support roller
Counting roll fingers
Upturned pieces return to hopper
Slide
Counting roll driven intermittently
Plan View of Slide
Bearing cap, typical part to be handled
Detail shows rails removing upturned pieces

FIG. 1

successive parts carried to this point by the drum will pass over the last piece on the slide, remaining in their hole in the drum until they pass the drum delivery point again and find it unoccupied. Dividing the counting roll into the proper number of segments, and rotating it through part of one revolution will count pieces as required by different applications.

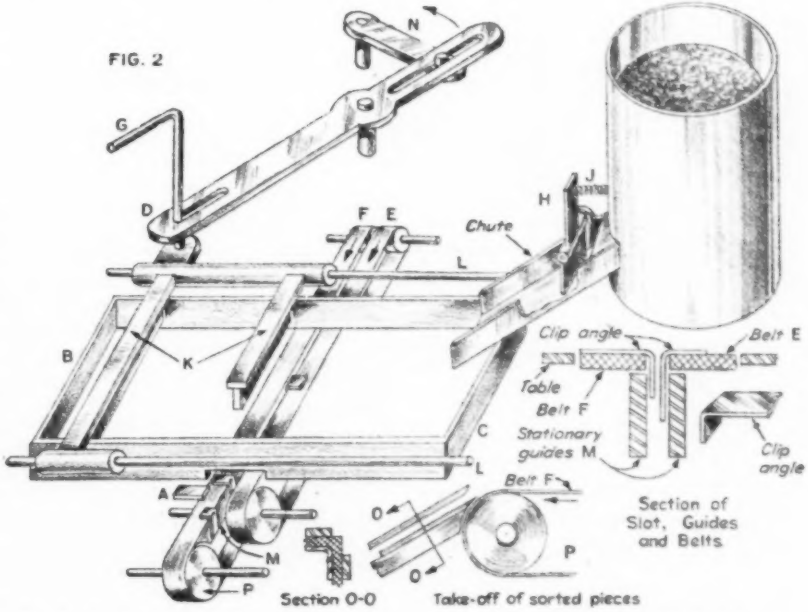
for design of feeding, sorting and counting mechanisms

illustrated and are presented as a guide to the designer faced with this type of problem. Two other designs, interesting examples of devices now being made and sold as standard equipment by well known companies, have been included to broaden the scope and utility of the article. These 12 designs should solve a big percentage of industry's feeding, sorting, and counting problems. However, they are not presented as the definitive work on this subject. Variations are of course infinite; each part must be handled as a special case, but the development work involved is made increasingly worthwhile by rising labor costs and the distaste, even of unskilled labor, for monotony. The recommendations checked in the accompanying table will furnish a rough guide to designers. Where several selections can handle a given type of material or component the simplest design should be chosen, and must be modified to meet the special requirements of the particular job. Quantities of pieces to be sorted, space requirements, speeds required, and other such factors will also enter into the selection of these mechanisms. Full-scale models must be built and thoroughly proven before these mechanisms can be placed in production, but their construction is not too expensive because wood, plastics, and sheet metal can be used for many parts.

2. Reciprocating Wiper Feeding and Sorting Device

A clip angle with unequal legs is to be chute-fed. The parallel wiper bars K-K move between the end rails B and C, positioned by the rods L-L and driven by the crank N. As they reach the right end of travel, projecting bar G strikes the pivoting gate H, which swings to pass a few parts down the chute from the hopper. The timing is such that they fall between K-K. The spring J keeps the gate closed unless struck, and feed can be regulated by lowering or raising G. As the wiper bars move to the left, the mass of parts is piled against the right hand one, and as it pushes them over the slot in the table between belts E and F, some will drop one flange into the slot. These are carried outwards by the belts, and restrained from falling through by the guides M-M. Clearance between the bottom of the wiper blades and the table is such that the wipers pass over parts falling into the slot. If only one line of clips is needed, belt E dumps its load into a bucket below the delivery end pulley. Belt F is also carrying parts, but half will have their long leg lying across its top surface. A block A positioned just above belt F and projecting inwards just far enough to be struck by the long leg of the clip but not by the short one, will knock off any clips which are improperly oriented. Takeoff from the belt to a chute is shown in Section 0-0, where a knifedge angle will pick clips off the belt.

FIG. 2



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3. Sorting Mechanism for Tube-Fed Long Parts

This device, shown end-sorting studs so that all studs enter the funnel with the stud end down, has the advantage that all parts continue in one stream; synchronization of the shaft drive with other equipment can time or count the discharge. The spider has at the end of each arm a cup with an OD equal to that of the part and an ID slightly larger than the small end. While the shaft is making a quarter turn, the edge of the rubber cam projects into the tube, holding the next piece from falling until one of the cutouts appears. Timing is adjusted so that a piece hits the cup just after it is aligned with the tube centerline. If the stub end of the part is down, it will rest across the rim of the cup. After the dwell period of the intermittent-drive the spider moves again, and the cup jerks out from under the stud, the stud falling into the

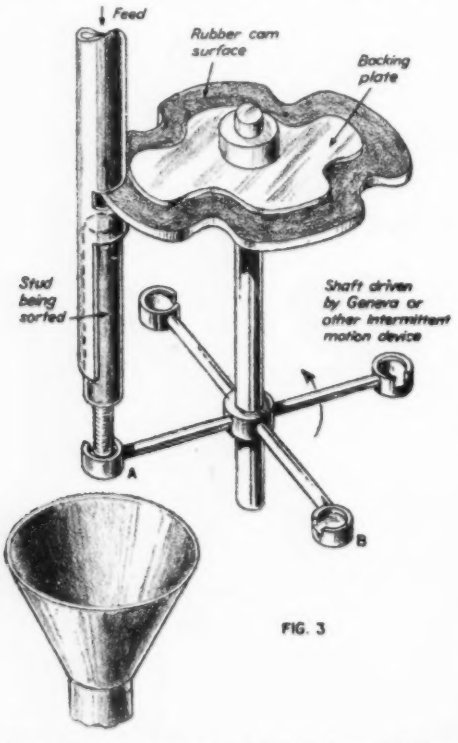
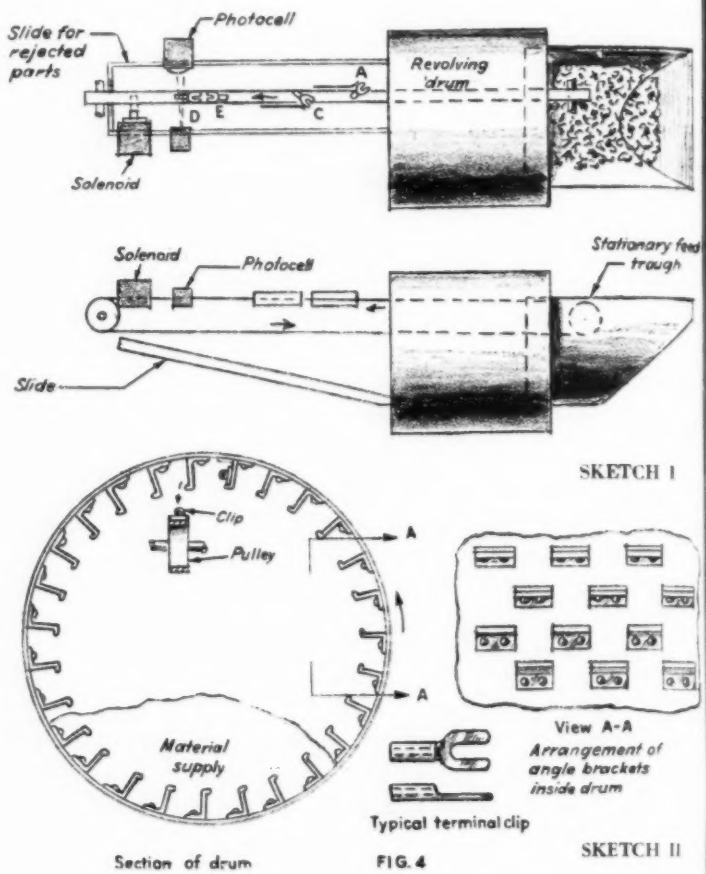


FIG. 3

funnel below, the stub end still down. When a part drops small end down, the small end will drop into the cup. The arm starting to move, the end is held by the cup, and it moves away from the tube, which is split here so that the upper end slides along it. When the cup reaches some position between A and B the top end is no longer supported, and it drops. When the stub end is below the level of the cup the small end slides off the rim, and the piece drops stub end down.



4. Drum-and-Belt Feeding, Sorting Hopper

The drum is end-fed from a fixed trough, and is lined with angle brackets staggered in arrangement and having small lips. The brackets are just large enough to hold one piece, though in operation others will cling. As the terminal clips illustrated ride into the upper right quadrant of sketch II, most parts not securely resting on the brackets will fall. The belt is so placed that parts tipping out of the brackets above will fall onto it; many will of course bounce off if the drop is too great or the belt too resilient. The belt carries the clips past the fixed guides A and B, which either line them up with the belt or push them off. The photocell light is interrupted by the high part of the clip, (the wire ferrule), which, with a suitable time delay circuit corresponding to the time of belt travel from the cell to the solenoid, energizes the solenoid. The solenoid plunger extends and retracts quickly; if the clip is turned like D on sketch I, the plunger hits nothing, but if it is turned opposite like E, the forked part of the clip is in the way and the solenoid plunger knocks the clip off the belt. A trough below the belt slopes down, carrying rejected clips back into the drum. If this feature is unnecessary, the lips on the angle brackets inside the drum may be omitted, and the belt located just above the center and near the right side of the drum. In the case of the clips illustrated, the proportions and speed of the drum and belt may be adjusted so that only pieces falling to the belt with their flat sides down will remain on it. This type of hopper is adaptable to a very wide variety of parts which tangle, nest, or have wires attached. When the drum and belt are properly proportioned a rain of parts strikes the belt in such numbers that even though a small percentage are properly oriented the output is large.

5. Turntable Hopper

Any solid part which will easily orient itself into a round hole and which is not too thin may be handled by this design. The square hopper has a rubber boot around its outlet, which ends just above the turntable. Radial lines of holes in the turntable pick up pieces as they pass under the boot, and a few others besides will lock into the edge of a hole and be pulled out of the boot. These latter are removed by the stationary fence. After passing under the fence, a filled line of holes passes to the discharge sector opposite the hopper, where a dropping gate occupies a slot in the stationary plate under the turntable. Obviously all the holes in a line may not be filled, and it would not be desirable to dump these. A line of microswitches, supported slightly above the turntable, have rollers with "feel" for the piece, which must project slightly above the turntable surface. These switches are normally open circuit, and are wired in series. If all of an entire line of holes is filled, they will all close simultaneously, energizing the solenoid which pulls out the dropping gate. A belt is illustrated carrying off the discharge, but a tube or chute might be located under each hole at the discharge station. Another electrical device can energize the solenoid only when discharge is desired in synchronization with another piece of equipment; the holes will remain filled until the dropping gate empties them.

FIG. 5

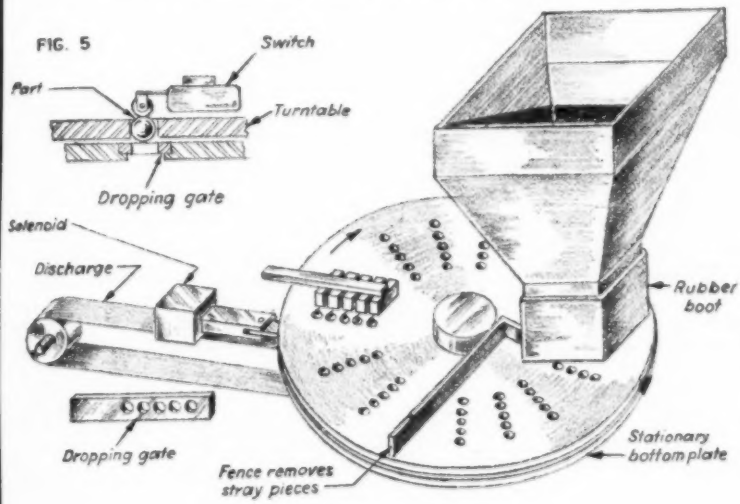
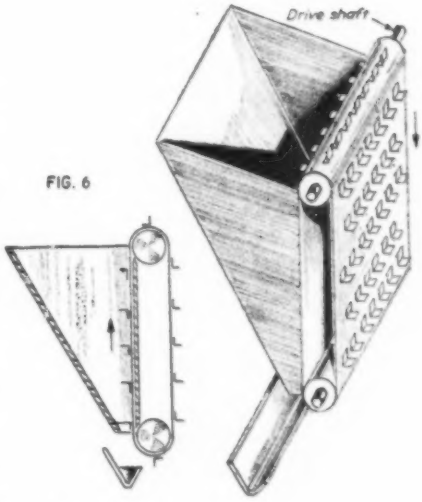


FIG. 6



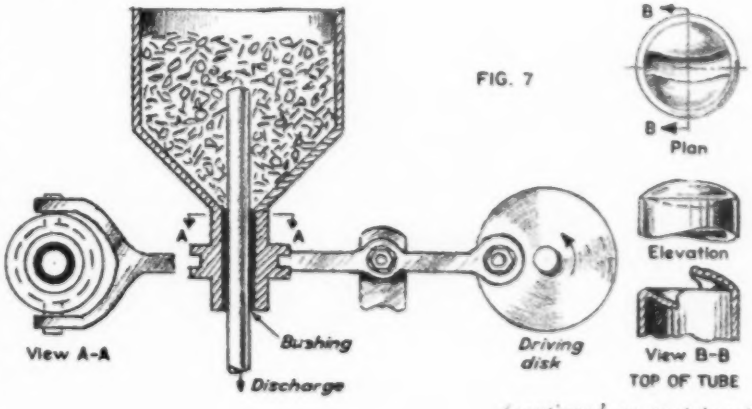
6. Non-clogging Stationary Hopper

Stationary hoppers handling granular materials can be equipped with electrical or mechanical vibrators to prevent clogging, but objects having a major dimension more than twice their minor dimension will clog unless the discharge opening is made several times their length. One positive anti-clogging device is the belt illustrated. The cleats are staggered in arrangement, wide enough so that the entire length of the discharge opening is frequently cleared, but too small and narrow to support a piece lifted out of the top of the material heap. The hopper may drop parts to a belt below, or be tilted so that the discharge opening is parallel to a sloping chute. When almost empty this type of hopper increases its rate of discharge, but the flow is quite constant from full to about one quarter full.

7. Coin Changer Feeding Mechanism

In this device, applicable only to round, flat objects, the tube is stationary. The funnel reciprocates, driving the tube end through the material heap; at each downward stroke one or more parts will be passed through the slot in the top of the tube. Lubricant on the OD of the tube will dirty and contaminate the pieces handled. If this is objectionable the bearing bushing must be dry, but lengthening it will extend its useful life. Parts which are too heavy will batter the end of the tube, and burrs will reduce the number fed into it. The clearance between the OD of the piece and the ID of the tube may be sufficient so the design can be applied to parts not too uniform in size.

FIG. 7



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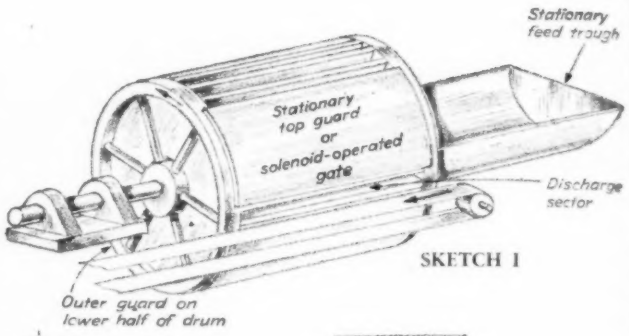
8. Bar-sided Drum Hopper

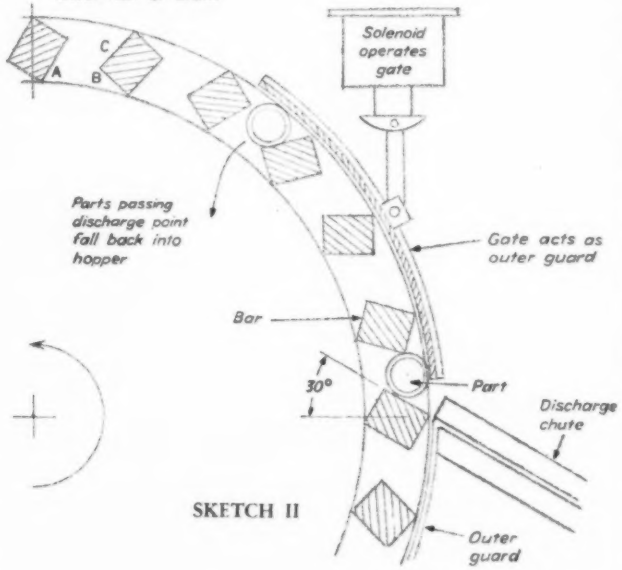
This design can be used in the random discharge version (shown in sketch I) for parts which tangle, since pieces not discharged are thrown back into the heap at the bottom. Sketch II shows the arrangement of the bars; the outer guide ends at the discharge slide or belt, with the bar at the discharge point sloping at the same angle as the slide.

Sketch III shows how the design can be adapted to discharge more than one stream of material by dividing the openings with separators, but parts which tangle would clog the openings. Cylindrical objects can be discharged at a timed rate or synchronized with other mechanisms according to the operation of the gate solenoid.

Looking at sketch II upside down, the bottom pair of bars at the centerline will be seen to form a funnel shape between surfaces A and B, which facilitates the parts dropping onto surface C, on which they ride in the lower half of the drum. An inner guide may be fitted into the upper half of the drum, in which case the spaces between the bars will remain filled until each slot passes discharge point and finds the gate open.


Stationary feed trough
Stationary top guard or solenoid-operated gate
Discharge sector
Outer guard on lower half of drum

SKETCH I



SKETCH II

SKETCH III

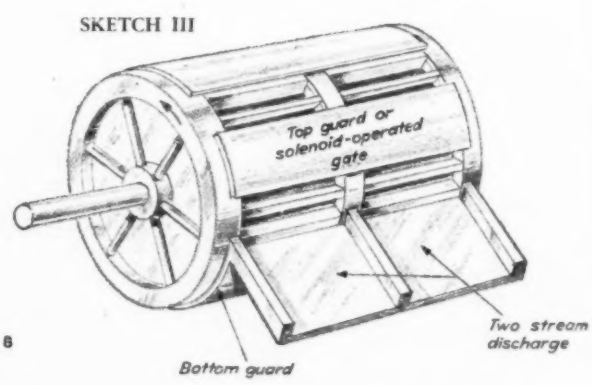


FIG. 8

9. Power Screwdriver Hopper

One of the oldest and most popular feeding and sorting devices, this design has been adapted to a variety of symmetrically shaped parts. The wedge-shaped blocks fastened to the rotating ring are spaced so as to permit the part to fall between them when they pass under the supply stored inside the cover. The baffle plate inside the rotating ring is stationary, being attached to the fixed central shaft which also supports the discharge track. This baffle plate keeps the 50 caliber bullet cores illustrated from falling inwards until they are carried up to the end of the track. The selector guard attached to the baffle plate allows bullet cores oriented point first to pass into the track, but rejects those having their blunt end down. For parts which are bulky and which must be fed at a high rate this hopper must be equipped with an auxiliary device to dump batches of parts inside the cover every few minutes, since the cover cannot hold a very large supply. This hopper is usually driven by a constant speed motor, a feed limiting device or escapement being used to regulate the discharge. Feeds as high as 300 parts per minute can be obtained, but light plastic or sheet metal objects must be discharged at a much lower rate.

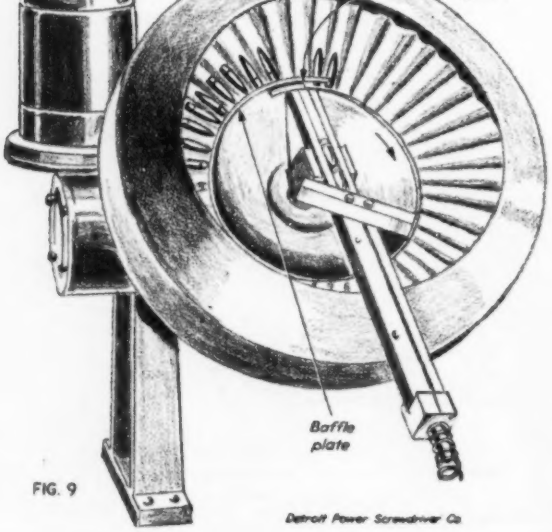


FIG. 9

10. Squirrel Cage Feeding and Sorting Hopper

Rubber parts are difficult to sort because of their high coefficient of friction and resilience. These rubber casters, pressed into the bottom of small electrical appliances, could not be handled in any device dropping them even a short distance, and their center of gravity is such that orientation by movement would be difficult. However, lying in the outer cover of this hopper, they are tumbled until each piece happens to orient itself with the shank down. A slot passes under them, and they drop into it when other pieces permit. As the hopper turns clockwise, the caster lying with its shank in the slot between two wedges is carried into the upper left quadrant, where the inner guard keeps it from falling out. The inner guard ends at top center, where the chute picks up whatever pieces are in each slot and removes them. The weight of the piece is taken at point contact with the bottom rail, the top rails being stabilizers. This type of chute is best for rubber and other high-friction materials because it is open for clearing jams, has little frictional resistance to movement, and is easy to fabricate. It will handle cubes, long cylinders and other shapes, and is especially good for material that have a high coefficient of friction.

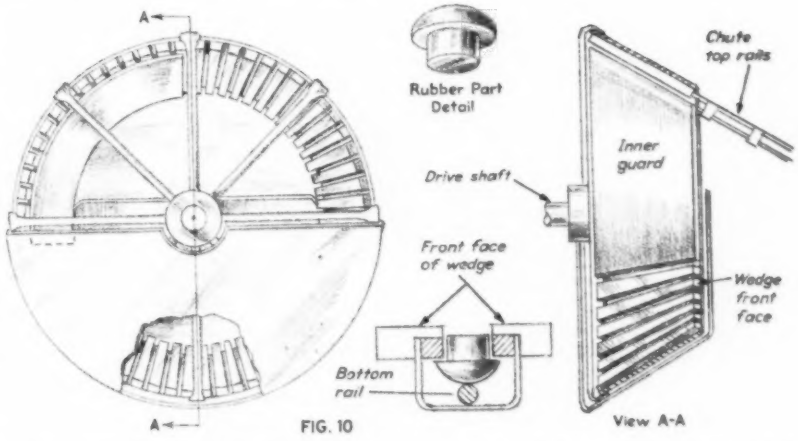


FIG. 10

11. Piston Hopper

Materials too fragile to be tumbled or agitated can be fed from this design. The chute angle should be approximately equal to the angle of repose of the material. The drive pinion may be driven by a variable speed motor and gear train, or the screw feed replaced by a hydraulic cylinder. A surprisingly constant flow of material can be maintained, but additional regulation by adjustment of the pivoting gate is difficult unless accompanied by control of the piston feed.

12. Vibratory Bowl Feeder

In this design a bowl is placed above a vibrator and shaken at 60 cycles by an AC solenoid. The center of the dish remains relatively motionless, since the direction of vibration is normal to a radius. Vibration sets up forces which drive parts to the periphery of the bowl, where a spiral track guides them up to the rim of the bowl. The base containing the vibrator is a standard unit, but the shape of the bowl and track are determined by the objects to be handled. Rate of feed is controlled by a rheostat which varies the amplitude of vibration; it is not normally necessary to vary the frequency. Multiple streams of parts can be discharged by making the helical track of multiple pitch like a screw thread. Gates, fences, air blows, or variations in the shape of the track at one point can discharge pieces which are improperly oriented. With proper design and regulation the discharge can be blocked awaiting the needs of the associated equipment, or the vibrator can be turned on and off by counting devices.

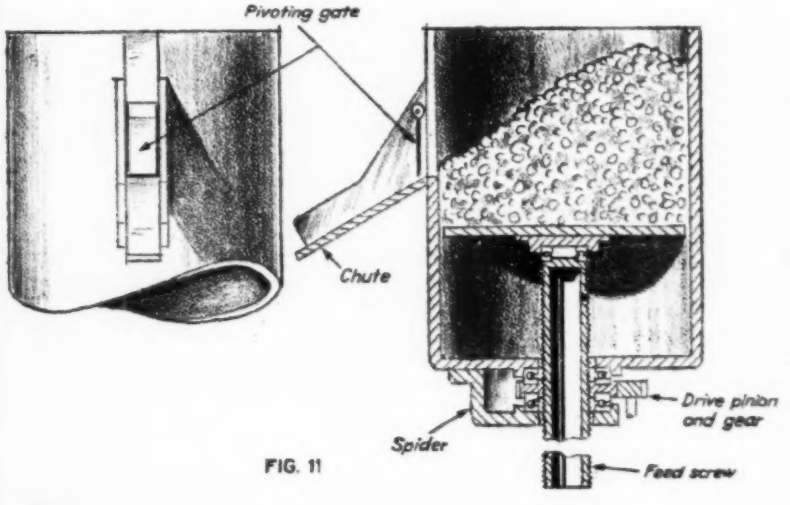


FIG. 11

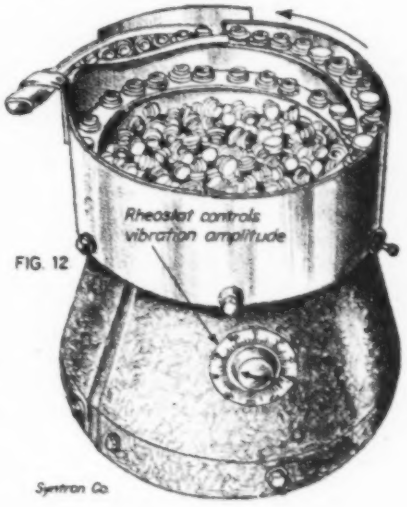


FIG. 12

ENGINEERING ABSTRACTS

FOREIGN AND DOMESTIC ARTICLES

Invention and Engineering Facts

Abstracted from the James Clayton Lecture, "Invention and Sifting Out Engineering Facts" by E. G. Bailey, past president, of ASME, delivered in London April 22, 1949. Proc. The Institution of Mechanical Engineers, Vol. 160, pp 196-207.

HIGH SPOTS of the paper are: Relation between research and invention, with a plea that research be conducted along lines that will result in more valuable inventions; incentives to invention; steps in the practical application of inventions; trends in the invention of products and processes, communications, transportation, and power and heat.

Under the heading "Specific Procedure for Invention", Mr. Bailey states:

(a) Study the previous work and present practice on the subject sufficiently to acquire aid, but not so much as to become discouraged or distracted from the right answer, which may not yet be in the literature. Too much work in the library may be a waste of time, and probably more than too little time spent.

(b) Work with one's own hands within the field of activity involved. This is of such importance that it cannot be over emphasized. Acquire intimate knowledge of the problem and the limitations of existing methods and equipment.

(c) Give rein to intuitive, imaginative, and even "crazy" thinking. It may help to get out of a rut.

(d) Think without ceasing at any and all hours of the day or night, for suggestions or ideas may flash into the mind at any time. Invention and a 40-hour work week are strangers.

(e) Keep mental pictures and drawings in a formative status at all times; review and change them as the work progresses: Be on the lookout for entirely new ideas when one first awakens from sleep.

(f) Perform the necessary experimental work to prove certain phenomena and relationships, since relatively few inventions can be completed without it.

(g) Work out all possible permutations and combinations of the several factors or increments involved in the device or method. The best design is seldom made first.

(h) Search diligently for the link which is often missing and most difficult to grasp. It may be an important factor or a secondary increment detracting from perfecting the whole. It may be necessary to keep a network of thoughts open for a long time while endeavoring to find the last link to complete the chain.

REDUCTION TO PRACTICE. Every worthwhile invention should be reduced to practice and thoroughly tested before it is placed into extensive use, in order to:

(a) Make sure that it performs as expected in the hands of critical operators and users, under a variety of conditions.

(b) Obtain criticisms and suggestions from others.

(c) Sift out facts and make improvements, if needed, as soon as possible. The pride of authorship should not be permitted to stand in the way of evaluation of the invention on its true merits.

(d) Avoid the inclination to make changes too frequently after the product is put to use, even though they may be improvements.

Effects of Additives on Corrosion Resistance of Stainless Steel

Foreign Abstract from "The Corrosion of the Austenitic Stainless Steels", G. T. Colegate, Metallurgia (London), April 1950.

MANY MODIFICATIONS have been made to straight austenitic chromium-nickel steels with a view to improving their corrosion resistance. The best-known, of course, are the additions of titanium and columbium for preventing intergranular attack. Besides these, however, various additions have been made with a view to improving general corrosion resistance. Some of the more important of these are discussed. In many cases, the addition serves more than one purpose, modifying, for example, the mechanical properties of the alloys or improving resistance to high-temperatures.

Molybdenum—Usually added in amounts varying from 2 to 4 percent, it improves resistance to intergranular corrosion and also resistance to pitting. It is in the latter connection that molybdenum is probably most valuable. It cannot be claimed that molybdenum additions are completely effective in suppressing pitting under all conditions, but the presence of the element has a very marked effect. For example, resistance to pitting is greatly enhanced in chloride solutions; a ferric chloride solution pits straight 18:8 chromium-nickel steel but the attack is far less pronounced if molybdenum is present. Molybdenum-bearing steels also show less tendency to pit in the sulphite solutions used in the paper industry and in weak acid solutions.

Resistance to various chemical solutions is also improved by the addition of a few percent of molybdenum to these alloys. Chief among these is sulphurous acid, though various weak organic acids such as acetic, oxalic and formic give appreciably less attack on molybdenum-bearing steels than on straight chromium-nickel ones. The same also applies to hydrochloric and sulphuric acids. On the other hand, molybdenum additions tend to reduce the resistance of these steels to strongly oxidizing liquids.

Silicon—This element reduces the resistance of austenitic stainless steels to attack by nitric acid but improves their resistance to hydrochloric, sulphuric and other acids. Besides this, silicon has very little effect on the general corrosion properties of this type of steel, except, of course, on its resistance to high-temperature oxidation.

Copper—This is an element which has been used commercially as an addition

to austenitic stainless steels for the purpose of improving corrosion resistance, the amounts used varying between 2 and 6 percent. The presence of copper improves resistance to chlorides, including dilute hydrochloric acid and brine. It is also claimed that the higher amounts of copper improve resistance to scaling at high temperatures.

Additions of copper to austenitic stainless steels increase their resistance, under certain conditions of exposure, to corrosion by sulphuric acid. The presence of small percentages of copper greatly reduces attack by this acid, the optimum effect being at about 2 percent copper. It is not claimed that such copper additions are of benefit under all conditions of exposure; for example, there is no improvement in the behavior of these steels in contact with acetic acid or nitric acid.

Selenium and Sulphur—Sulphur has very little effect on the corrosion resistance when present in amounts up to about 0.40 percent, the amount of sulphur sometimes added to confer free-machining properties on these steels. Selenium, on the other hand, does reduce corrosion resistance slightly when present in amounts of the same order, though the reduction is so small as to have little practical significance. There is, however, a certain amount of evidence that selenium additions tend to increase the tendency of these steels to pit, especially in solutions such as ferric chloride. The effect is less pronounced in sea water. The article goes into detail on each additive and its effects.

Electronic Switching in Machine Control

Abstracted from "Engineering Trends in Spot Welder Controls" by Stuart C. Rockafellow, from "Electronics", a McGraw-Hill Publication, p 70, July 1950.

ELECTRONIC SEQUENCING becomes advantageous when operating speed is stepped up. Relays have an inherent delay which limits their speed in changing from one circuit to another. Tubes replacing relays can make a change instantly. Small thyratrons are generally used due to their high current-carrying capacity and ruggedness. In timing circuits these tubes are desirable because the current they control is either on or off. They act more like a complete switch than a vacuum tube.

The Robotron timer, designed for sequence control of welding machine operations, is an application of electronic machine control. The schematic diagram, Fig. 1, shows the functioning of the control.

The thyratron, being a grid-controlled rectifier, will conduct only when its anode is positive. The tube can be rendered nonconductive if a negative charge is placed on the grid between positive pulses.

When the circuit of Fig. 1 is at rest, tubes V_3 and V_5 are conducting, charging weld time capacitor C_3 and hold time capacitor C_5. The squeeze time capacitor C_1 is charged by grid-to-cathode conduction of V_2 through R_3. Capacitor C_2 is being charged to a negative potential at its grid end by grid-cathode conduction of V_2.

When the initiating switch is closed, relay 1 is energized through V_1 and all of the contacts on it are closed. One set of contacts is used to lock in around the initiating switch and the other set to bring the cathode of V_2 to the potential of the L_1 side of the a-c line. The cathode end of R_1 is now at L_1 potential and the charging source for C_1 is removed so it now discharges through variable resistor R_3 for squeeze time.

When C_1 drains to a low enough value, tube V_2 will conduct and pull in relay 2 which starts the weld time. When V_2 conducts, the positive pulses which have previously been used to charge C_2 are effectively shorted to the L_1 side of the line. This brings the anode side of C_2 to L_1 and V_3 is blocked by a negative potential. With V_3 rendered nonconductive, C_2 now drains through variable resistor R_4 to a low enough value so that tube V_4 conducts, giving the weld time.

When V_4 conducts, C_4 immediately charges to a negative potential at its anode side. This places a negative potential on the shield grid of V_5, which stops that tube from conducting, releases relay 2, holds V_3 nonconducting and blocks V_6. With V_6 blocked, C_5 can now drain through variable resistor R_5 (hold time) to a low enough value until V_6 will fire. When V_6 fires, the negative charge on C_6 is fed back to the grid of V_1, blocking that tube and releasing relay 1.

If the initiating switch is held closed, as is done in repeat operation, then as relay 1 opens at the end of the cycle the anode supply to V_4 is broken, rendering that tube nonconductive. This in turn releases the negative bias on V_2, V_3 and V_5 and these tubes immediately conduct, charging C_3 and C_5. As C_3 charges, it blocks V_4, which then allows C_4 to drain to a low enough value through variable resistor R_2 (off time) until V_1 fires again, starting another sequence.

The techniques and circuits de-

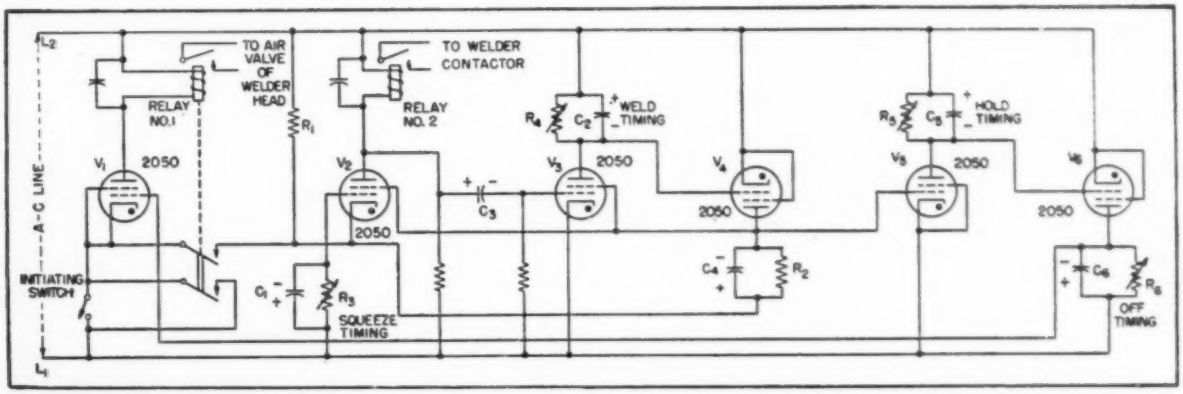


Fig. 1—Simplified circuit diagram of a sequence timer used in resistance welding machines. At-rest condition is shown, in which V_3 and V_5 are fully conducting and the grid-cathode path of V_2 is conducting.

scribed are readily applicable to other types of industrial electronic controls. The design principles involved are basic to widespread industrial acceptance of electron tube equipment on factory production lines.

Cast Aluminums at Elevated Temperatures

Abstracted from the article "Fatigue Properties of Four Cast Aluminum Alloys at Elevated Temperatures", by J. McKeown, D. D. Dineen, and L. H. Back in Metallurgia, May, 1950.

AN INVESTIGATION HAS BEEN UNDER WAY to evaluate the mechanical properties of light alloys at elevated temperatures by the British Nonferrous Metals Research Association. To date the results of this work give important data on four cast aluminum alloys. The compositions of these alloys are given in Table I. The effect of temperature on the endurance limit is shown in Fig. 1. The endurance limits in this graph were determined after 50 million cycles of loading.

Three alloys (D.T.D. 424, Y-alloy, and Lo-Ex) were found not to show any appreciable change in properties with temperatures up to 200 C. This condition was considered as a heat-treatment effect due to the elevated temperature testing conditions. To verify this, samples of D.T.D. 424 (which were not previously heat-treated) were precipitation-hardened by soaking at test temperatures for as long as 24 hours. As a result, an increase in hardness was found on the samples up to 200 C and a decrease on those soaked at 300 C; this corresponded with the test data.

Although the Y-alloy and Lo-Ex were heat-treated, (solution treatment at 510 C for 6 hours, cooled rapidly to room temperature, and aged at 175 C for 10-12 hours) the aging treatment did not completely stabilize these alloys. Further precipitation must have occurred during the period of testing at 100 C, although this could not be verified metallographically.

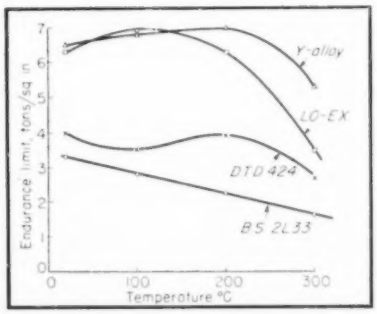


Fig. 1—Effect of temperature on endurance limit of cast aluminum alloys.

The tests were conducted on a rotating, cantilever beam using the B.N.F. Rotating Load Fatigue Testing Machine and specimen of 0.550 diameter and 6.8 in long. This machine was operated at 3,000 rpm.

Helium Leak Detector

Abstracted from "Leak Detectors for Industrial Vacuum Systems", by Andrew Guthrie, page 96 of the September 1950 issue of Electronics, a McGraw-Hill publication.

THIS SIX-PAGE ARTICLE, based on a forthcoming book, analyzes 8 methods of locating and measuring leaks in vacuum systems. Major emphasis is on the helium leak detector, which rapidly indicates by meter and audio tone the presence of helium ions inside a leaky system when helium gas is applied outside. Repair techniques are also covered.

The locating and repairing of leaks in vacuum systems is probably the most troublesome aspect of high-vacuum technique. The ideal leak-detecting method should be capable of measuring total leakage and isolating individual leaks, should be rapid in response, should not seal the leak more than momentarily. It should be highly sensitive, should be capable of application to any vacuum system without loss of vacuum if necessary, and should make use of equipment that is relatively simple and inexpensive to procure, maintain and operate. It is also highly desirable that the instrument used be selective, so that it gives nearly a zero reading for air and residual gases and responds only to a probe material.

A large number of leak detection methods have been reported in the literature or have come into use in various laboratories without being made generally available. Some of the most useful of these methods are summarized in a table in this paper. Several are limited in sensitivity primarily by the type of indicating device used. Most of the methods are not particularly suitable for obtaining an accurate determination of the size of a leak. However, in many cases this is not too important, the problem being to locate and repair the leaks as rapidly as possible.

Each of the eight methods listed has its place in vacuum technique, but the helium leak detector is the most generally useful for locating vacuum leaks rapidly. The article describes in detail the basic principles of operation of the helium leak detector with the aid of cross-section drawings and circuit sketches. The instrument is for the most part electronic in nature.

Using reasonable care in operation, the helium leak detector should be capable of detecting 1 part of helium in 200,000 parts of air. The sensitivity is limited by base noise level, which is due to noise inherent in any a-c amplifier, pickup of stray frequencies near the signal frequency, ion background from elements other than helium, and a helium background of at least 1 part in 670,000 (normal atmospheric concentration) and often greater due to contamination and leaks.

Also covered in the article is a discussion of the leak hunting techniques recommended to the user of the detector. The exact methods to be used in applying helium depend on the circumstances and the alertness and ingenuity of the operator. In general, a compromise design is necessary.

Table I—Composition and Tensile Properties of Cast Aluminum Alloys

Material	Specifications: Alloying Elements in percent								Properties		
	Cu	Fe	Si	Ni	Mg	Mn	Ti	Zn	Temp °C	0.1% Yield Stress Tsi	Ultimate Strength Tsi
1. Cast 12% Silicon Aluminum Alloy B.S. 2L33	0.06	0.30	12.3	....	....	0.03	0.01	....	100 200 300	3.4 2.8 1.0	9.2 6.2 4.2
2. Cast Aluminum Silicon-copper Alloy D.T.D. 424	2.94	0.76	4.52	0.32	0.03	0.44	0.12	....	20 100 200 300	6.0 4.9 5.5 4.4	10.6 10.1 9.5 6.2
3. Die-Cast Y-Alloy B.S. 704	4.44	0.29	0.15	2.11	1.63	0.02	0.04	0.04	20	...	22.8 to 24.4
4. Die-cast Lo-Ex Alloy	0.89	0.46	10.62	2.59	0.77	0.01	0.02	0.06	20	...	21.4 to 23.2

TECHNICAL NEWS

Defense Production Keynotes Metal Show

INCREASED PRODUCTION FOR NATIONAL DEFENSE is the theme of this year's 32nd National Metal Congress and Exposition to be held in Chicago, October 23 to 27. All of the participating societies in the Metal Congress will recognize the extreme importance of high production in their various technical meeting and seminars. These societies include the American Society for Metals, who sponsors the affair, the American Welding Society, the Metals Institute Div. of the American Institute of Mining and Metallurgical Engineers, and the Society for Non-Destructive Testing. In addition to these meetings, the show itself, which will be held in Chicago's International Amphitheatre, will have for its theme the idea of material and equipment for high production. In this year's exhibit approximately 350 nationally known firms engaged in either the production of metals, the treatment of metals, their fabrication or in rendering services to all of these will exhibit their products and equipment in the amphitheatre. Technical meetings will be held in the Palmer House, Sherman, Sheraton and Morrison hotels.

Special events of the exposition will include the Business Forum of the American Society of Metals, at which top management executives of metals producers and of the five principal metals consuming industries will meet together to discuss present problems and future prospects of the metalworking industry. This is a "first" for the Metals Show.

At the Business Forum, the producers of raw materials, both ferrous and non-ferrous, will report on the prospects for a continued high level of output, on the needs and the opportunities for expanding present plant facilities and on the more critical implications of domestic and foreign supply, should the present world tension grow worse.

The automotive industry has its answer among the consumers of metals and a top rated man in this field will be there to tell about it. The railroad, agricultural equipment, chemical and electrical industries will report in a similar manner.

Sales Clinic

Another first for the Metal Show will be the ASM Sales Clinic, conducted in the interests of industrial exhibitors and those who need and can use the benefits of other experiences in marketing and distribution of industrial products and equipment. Mr. C. T. Burg, General Salesmanager of the Iron Fireman Manufacturing Co. will present a message fitted to the special requirements of industrial sales at two meetings. The industrial trade show problems will be considered at the first session, Sunday evening, October 22nd, at 8 pm. Panel discussions will follow the principle address, with prominent publishers and editors of trade media acting as the experts on the platform. The second meeting, Tuesday morning, October 24th at 9, will be devoted to the broader aspects of industrial selling and marketing.

Industrial Motion Pictures

The success of the "Economy Theatre" presentation during the 1949 Metal Show in Cleveland called for a repeat performance at the Chicago Show this Fall. Exhibitors having films depicting techniques and methods which contribute to high productivity in plant operations will again have available the professional facilities for showing those films to an active and interested audience of technical, production and management men in the metalworking industry.

Technical Sessions

The four sponsoring Societies, through their scheduled seminars, lecture sessions and meetings on technical subjects pertaining to metals production, treating and processing, will provide Show visitors with daily opportunity to hear vital technical subjects discussed and analyzed. The American Society for Metals and the American Welding Society will hold morning, afternoon and evening sessions throughout the week. The Metals Institute Division, American Institute of Mining and Metallurgical Engineers will have daily and evening sessions Monday through Wednesday. The Society for Non-Destructive Testing have scheduled morning and afternoon technical meetings on Tuesday, Wednesday and Thursday. The ASM Educational program will be covered by three series of lectures on Monday, Tuesday and Wednesday, October 23, 24 and 25. The subjects: "High Temperature Properties of Metals", "Interpretation of Tests and Correlation with Service", and "Metallurgy of Titanium". The American Society for Metals technical contributions will also include Society's Seminar on Atom Movements, held on Saturday and Sunday prior to the Exposition opening on Monday, October 23rd. The ASM Metallographic Exhibit will also

be on display on the floor of the Amphitheatre during the entire five-day Show.

For a complete roundup of new developments in the field of metals, the reader should refer to page 87, of this issue, to the feature article "Whats Ahead In Metals."

Signal Corps Develops Lightweight Battery

A NEW METEOROLOGICAL BATTERY developed by the Signal Corps Engineering Laboratories, Fort Monmouth, N. J., packs a great deal of power in a small space. The new magnesium-cuprous chloride battery, capable of powering meteorological equipment such as radiosonde to heights of 30 miles into the stratosphere, culminates years of work to find a compact, lightweight battery that could meet the desired standards.

Because it can be activated with ordinary tap water the new battery is much simpler to use than the lead-acid unit. Activation was a definite problem with the latter type. Several methods were invented to inject acid into the battery, but each proved messy, often times dangerous. One includes the use of an ordinary hypodermic needle.

Once activated, however, the new magnesium-cuprous chloride battery will operate efficiently in temperatures 65 deg below zero.

Engineers are quick to point out that the new battery will not be satisfactory forever. As weather equipment climbs higher into the stratosphere for more data, on which to base better predictions, better batteries will be needed.

All-Magnesium Airplane Planned

AN ALL-MAGNESIUM-ALLOY AIRPLANE is now in the planning stage by the Air Force, engineers in Air Material Command's Aircraft Laboratory report.

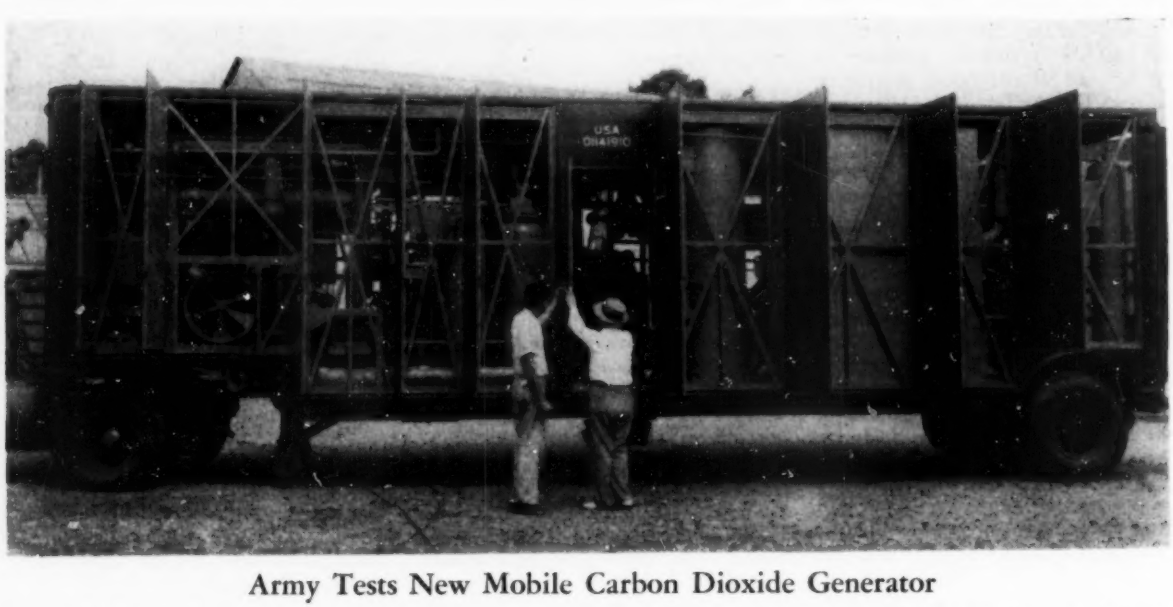
The construction of such a plane is considered practical because of the successful application of magnesium to structural components, especially in tests on the wings of the Lockheed F-80 fighter. These wings, made entirely of magnesium-zirconium alloy, employ a thick, unreinforced skin as surface covering in place of the conventional stringer-reinforced, thinskin type of construction.

The new type of wing has already undergone extensive static tests and has been test-flown on the F-80 for a total of 120 hours without showing any adverse structural characteristics.

Although its skin is more than seven times as thick as that of the conventional wing, the magnesium wing is believed better because very few internal reinforcements (stringers and chordwise formers) are needed to prevent buckling at high loads. This leaves considerably more space for larger fuel tanks. As a result, the improved wing and greater fuel load increase the range of the F-80 by approximately 30 percent, based on the wing alone.

Only about 25 percent of the detailed parts and fastenings used in conventional wing construction are contained in the new magnesium wing. One example of its simple construction is the fuel door. This is now simply a heavy plate, completely free of internal reinforcements. The conventional fuel door was made of relatively thin skin reinforced by stiffeners.

Both magnesium alloy and aluminum alloy have been used in the



Army Tests New Mobile Carbon Dioxide Generator

A MOBILE CARBON DIOXIDE GENERATOR of the fuel oil type that ups production capacity from 156 to 300 pounds per hour is currently undergoing tests at the Engineer Research and Development Laboratories at Fort Belvoir, Va. Designed to operate efficiently in any climate, the plant is only 12½ feet high, nine feet wide and 35 feet long. Its gross weight of 43,000 pounds is borne by 12.00 x 20 pneumatic tires in dual arrangement. Commercial plants of the same capacity weigh about twice as much and occupy roughly twice as much space, ERDL engineers point out. The new generator has all the essential features of large scale CO_2 generating plants, despite sharp military limitations on weight and dimensions. The gas produced will be used by the army corps of engineers for fire fighting, therapeutics, food preservation and beverage carbonation.

thick-skin type of construction and both were found satisfactory. However, in case of emergency, aluminum would probably be harder to procure than magnesium.

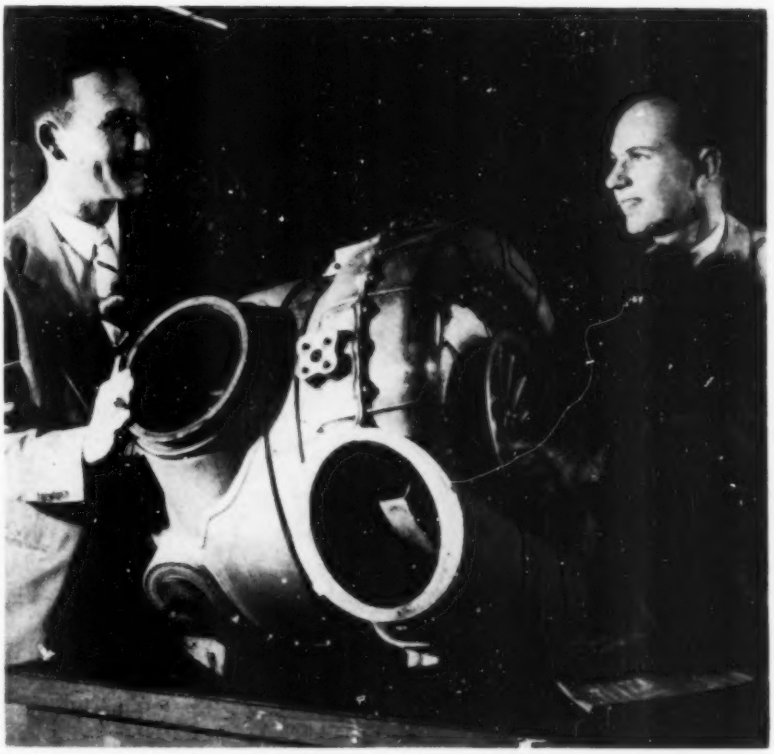
Portable Glass-Nylon "House" Passes Military Tests

A PORTABLE TENT in which even the tent poles are made of glass-and-nylon fabric has just gone through a series of successful tests at the Air Material Command laboratories in Dayton, Ohio.

The shelter was developed by the B. F. Goodrich Company for use as a field photo laboratory. The structure is waterproof, fireproof and will not admit light. The tent covering, which comes in sections, is zipped together over supporting members which are actually air tubes made of the same material as the cover. These low-pressure tubes can be inflated by an air pressure of three lb. The entire shelter can be erected by six men in about an hour and a half. A 40-mile-an-hour wind won't turn it over.

The fabric house measures 20 by 80 feet and is 16 feet high. It weighs 750 pounds and can be "knocked down" into a bundle 4 by 4 by 10 feet.

Although its primary uses at present are as a field photo lab or a briefing room, it can be adapted to a variety of other uses, the Air Force reports.



Lightweight Turbosupercharger Eliminates Gearing

A NEW TURBOSUPERCHARGER—the General Electric CH9—has been tested on the Pratt & Whitney R-4360-C engine. The new turbosupercharger utilizes a new power cycle that simplifies the engine, at the same time adding more power. It eliminates the conventional geared supercharger, or impeller, and permits operation without clutches, gearings, or fluid discs. There are no mechanical connections between engine and turbo.

The GE CH9 turbo handles up to 350 pounds of air per minute, compressing it to a pressure of 50 inches of mercury, absolute. With accessories, the unit weighs a total of 300 pounds. Engineering results from the actual test stand installation of the combined powerplant show 32 percent more power in takeoff and 20 percent lower fuel consumption.

The geared supercharger was eliminated through the development of a direct cylinder fuel injection system on the R-4360 engine. As a result, the new turbo can provide full engine manifold pressure. An aftercooler makes a net reduction in cylinder intake temperature of more than 65 percent, substantially increasing power and safety margins. Better performance is further assured by the increased use of exhaust energy and simplicity of operation. Strategic materials have been reduced.

American Welding Society Plans Special Sessions

IN VIEW OF THE PRESENT WORLD CRISIS, the American Welding Society is deviating from its long established technical sessions program by presenting two types of sessions at its 31st Annual Meeting at the Hotel Sherman, Chicago, during the week of October 22nd. The first group of meetings will include the usual technical sessions, and the new type of program will cover subjects of special interest at this time.

The regular technical program will present about 70 papers in 16 sessions covering subjects of current interest. Many of the sessions will be devoted entirely to specific industries of military significance. Others will cover the latest developments and research in such processes as resistance welding, automatic welding, inert gas shielded arc welding and gas cutting.

There will be a third group devoted to general fields such as weldability, surfacing, flame hardening, arcs and electrodes, controls, research, education, maintenance and non-ferrous welding.

In addition to these outstanding papers selected by the Program Committee from those volunteered by welding engineers, the American Welding Society will present three symposiums on subjects of established importance to industry with speakers selected by the Society. One showing the economics resulting from good welding design and how it can be attained, will be held Tuesday afternoon, October 24th. On Tuesday evening another symposium will be presented on Applied Welding Engineering, which will demonstrate the proper application of welding processes. The third special session will be a panel discussion on Monday afternoon, October 23, sponsored by the Resistance Welding Committee, to determine the needs of industry in this field of activity.

The first special session, Design For Production Economics, was selected

USAF Air Material Command

USAF Gets Automatic Parachute

A BOON FOR HIGH AND FAST FLYING USAF AIRMEN is this new automatic opening parachute. At right, Capt. C. G. Whitney, Air Materiel Command test pilot sets two tiny dials—a timer and an aneroid element—prior to takeoff. If he should later be forced to bail out, he must only pull the handle pointed out at left and the pre-set mechanisms will open the chute when he has cleared the plane and fallen to a safe altitude. Use of the new release does not interfere with operation of the standard ripcord.

The FCC and Color TV

THE FEDERAL COMMUNICATION COMMISSION'S half-way decision on color television, left the door open for designers to improve on techniques and systems already demonstrated before the commission, including the Columbia Broadcasting System favored by the commission.

The proposed "bracket standards" for monochrome television sets present the first design-engineering problem to manufacturers. Sets must be constructed capable of operating within these brackets, that is, equipped with receivers to handle the scanning of both present system black and white pictures and the CBS system in black and white. This means a television composite video signal of substantially the type and proportion now employed in monochrome but with the number of lines variable from 15,000 to 32,000 per second and the fields ranging from 50 to 150 per second.

New receivers would have a manual and automatic switch to allow selection instantaneously between the two sets of standards falling within the range mentioned—one being the present monochrome standards and the other the proposed CBS standards. The receiver would have to be constructed so that it would produce pictures of equivalent size, geometrical linearity and brightness in each position of the switch.

Representative manufacturers believe that sets can be built to meet these specifications but whether it is possible to go into production as soon as the commission indicates is another question since it would allow practically no time for field testing. At least 30 days after the Commission's order setting up standards, manufacturers are expected to start making the sets.

In return for manufacturers cooperation, the FCC agreed to make no immediate decision on color but only to propose that color standards be adopted on the basis of the CBS system. Thus, proponents of new compatible systems or those who can show significant improvement on compatible systems since the record was closed last May have an opportunity to demonstrate them to the commission within a specified time.

CBS also is given the opportunity to demonstrate a tri-color tube or other means it may have developed of achieving large size, direct view pictures. Any improvements in horizontal interlace (for improving horizontal detail in the picture) might be shown to the commission.

The FCC made it plain that in es-

for two reasons: (1) The belief that welding and its allied processes offer significant opportunities for economics in productions, and (2) that the designer of products is the key man to effect these economies.

At a special luncheon preceding the technical session the subject will be introduced by Convention Chairman H. R. Morrison. The principal speaker at the luncheon will be G. F. Nordenholt, Editor, PRODUCT ENGINEERING.

Following the luncheon three papers will be presented. The first will point out to the employer the qualifications he should seek in a welding designer, and to the designer the qualifications he should acquire. This paper will be presented by T. J. Crawford, Consulting Engineer.

To show how a manufacturer has utilized good welding design to accomplish significant cost reduction and product improvement, Kenneth Jackson, Caterpillar Tractor Company, will discuss "Economies Accomplished by Redesign for Welding."

The last speaker, R. H. Bennewitz, The Linde Air Products Co., will illustrate, by a series of case histories, the principles the designer must keep in mind. The examples will be of the "before and after type" and will represent a variety of products, metal thicknesses, materials, and welding processes.

tablishing final standards a system must be chosen that produces a satisfactory color picture, is capable of operating through apparatus that is simple to operate in the home, and is cheap enough in price so as to be economically available to the American purchasing public. It definitely does not favor a system where only black and white receivers are cheap enough for the masses, and color is available only to those who can pay luxury prices.

Compatibility in itself is regarded by the commission as too high a price to put on color although it is conceded that if a satisfactory compatible system were available, it would certainly be desirable. No satisfactory compatible system was demonstrated to the commissioners, it was stated. Reference is to the CTI and RCA systems.

The commission acknowledges that a number of significant improvements and even new systems should be examined but in the face of this it announced that it would close the door to all of them if manufacturers did not go along on "bracket standards". The alternative would be a final decision in favor of the CBS system and complete industry confusion.

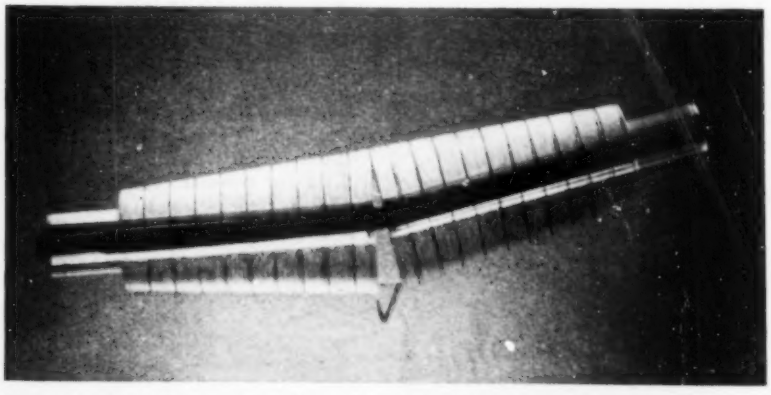
Navy Needs Civilian Engineers

THE U. S. NAVAL ORDNANCE PLANT, at Indianapolis 6, Indiana has announced that several Federal Civil Service positions are open at that station. The vacancies are for mechanical, electrical, electronics and ordnance engineers, and the salary ranges are from $3,825 to $7,400 per year. Full details can be obtained from Commander M. K. Coleman, USNR, Industrial Relations Officer of this station.

Self-Centering Roll Is Newest Conveyor Component

AN INGENIOUS NEW SELF-CENTERING ROLL promises to affect conveying methods for an almost unlimited list of materials. The principle of "planar action" was built into working models by E. T. Lorig, chief of the senior engineering staff of Carnegie-Illinois Steel Corp., and is now being used in various steel handling applications in Corporation operations.

Fundamentally the Lorig self-centering roll is a slightly crowned roll cut transversely at the center. The two halves are fixed to rotate as a unit. The working surfaces of the two parts are approximately horizontal, while the axes are at an angle. In this way, the planes, or lines of force in both halves twist evenly toward the center in the direction of movement, conferring a self-centering action on any materials passing over the rolls. Side-guides are consequently unnecessary to keep materials on the conveyor. A crown deviation of as little as 1/1000 of an inch from the horizontal is sufficient in a split roll to create the planar action which is the major force of the self-centering roll. The rolls have been tested for such a diversity of applications as runout tables, feed and guide rolls for electrolytic tinning, galvanizing and pickling lines, gravity conveyors, belt pulleys and conveyors and similar applications in the steel industry.



LINE OF FORCE "toe in" to the center of the Lorig roll, as shown by this Lucite model. When cut transversely, the working surface of the roll becomes approximately horizontal, and the planar action exerts a centering action on any material passing over the roll. This principle has been put to work by E. T. Lorig, chief of senior engineering staff, Carnegie-Illinois Steel Corp., a U.S. Steel subsidiary.

CARNEGIE INSTITUTE OF TECHNOLOGY will inaugurate its fourth president, Dr. J. C. Warner, and will celebrate its fiftieth anniversary on October 27 and 28.

•

THE EAGER BEAVER, Reo's newest Army Ordnance vehicle, is a 2½ ton truck designed to carry a 10,000 lb payload on a highway at 60 mph, or take that load up a 60 percent grade. It will cruise 340 miles at 35 mph.

•

THE THIRD BIENNIAL MATERIALS HANDLING CONFERENCE, sponsored by Westinghouse Electric Corp., will be held on October 24 and 25, in Buffalo, N. Y.

•

NEW AIR FORCE training planes made by Beech Aircraft Corp., have gross wt of 2,600 lb, and a top speed of 188 mph. The new YT-34 will serve in all phases of training, including primary, basic, and advanced.

•

THE ASTM is inviting criticisms and comments on its new Recommended Practice for Radiographic Testing. Interested persons should write to ASTM at 1916 Race St., Philadelphia 3, Pa. for a copy of the proposed Recommended Practice. Cost: 50 cents.

•

RECENT LEGISLATION sets up a clearing house for the dissemination of technological, scientific, and engineering information to American business and industry. The new law "legalizes" the function of the OTS, which has been operating under Presidential Executive orders since 1946.

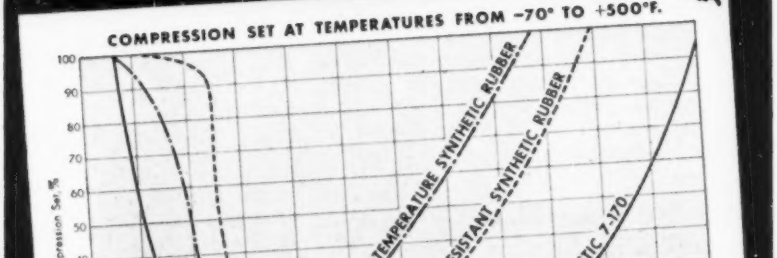
•

NEWEST MILITARY TRANSPORT PLANE has detachable fuselage, can be used like a truck-trailer combination. The Fairchild XC-120 made its first flight in August, staying aloft satisfactorily for 45 minutes with its cargo-carrying fuselage attached.

•

HIGH-STRENGTH PLANE SEATS facing the rear are being installed in Military Air Transport Service planes. The aluminum sheet seats are lighter, stronger, and safer, since humans riding backwards can withstand greater shock.

Where ordinary rubber gaskets fail . . .



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AT EXTREME TEMPERATURES, Silastic has greater resistance to compression set—or to permanent deformation due to heat and pressure—than any other rubberlike material. Its elastic memory exceeds that of both the best low temperature and the best high temperature organic rubbers available. Silastic 7-170 forms a more resilient seal at −50°F. than a special low temperature organic rubber does at −7°F. At 450°F., Silastic has more resistance to permanent compression set than the most heat-stable organic rubbers have at 330°F.

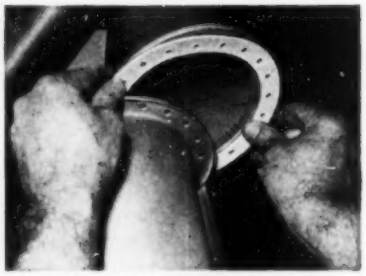

PHOTO COURTESY CONSOLIDATED VULTEE AIRCRAFT CORP.

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SILICONE NEWS

Dow Corning Silicone Insulation Saves Over $8,000 a Year on 4 Motors!

In the Saginaw Plant of Eaton Manufacturing Co., the output of four of these machines is stepped-up by stopping the 5 h. p., 3600 r.p.m. motors with a jolt of direct current as soon as 5 operations are performed on a small automotive part. With 105 starts and stops per hour, Class A insulated motors had an average life of only 8 days—32 failures for each of the 4 motors or a potential $10,000 a year in rewind costs alone.

Rewound with Dow Corning Silicone (Class H) Insulation, these motors now have a minimum life of 6 months; save Eaton a potential $8,000 a year plus a few hundred man hours of labor and some 40,000 parts that would have been lost due to down time.

DOWN TIME AND LOST PRODUCTION DUE TO MOTOR FAILURE ARE NO LONGER NECESSARY

Prove it in your own plant by having your hardest working motors rewound with Dow Corning Silicone Insulation. Call our nearest branch office for technical assistance or write to Dept. R-22A.

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MIDLAND, MICHIGAN

REMEMBER

Dow Corning Silicones Mean Business

Dihedral Angle Chart

M. WALD
Robins Engineers Div., Hewitt-Robins Inc.

IN DESIGN, the determination of the true angle between intersecting planes is often necessary. This is particularly true in designing chutes, bins, hoppers and sheetmetal work where parts must match after bending. Chart facilitates determination of this dihedral angle. In PRODUCT ENGINEERING, January 1950, a nomogram was given to find the dihedral angle between the sides of a truncated right-regular pyramid.

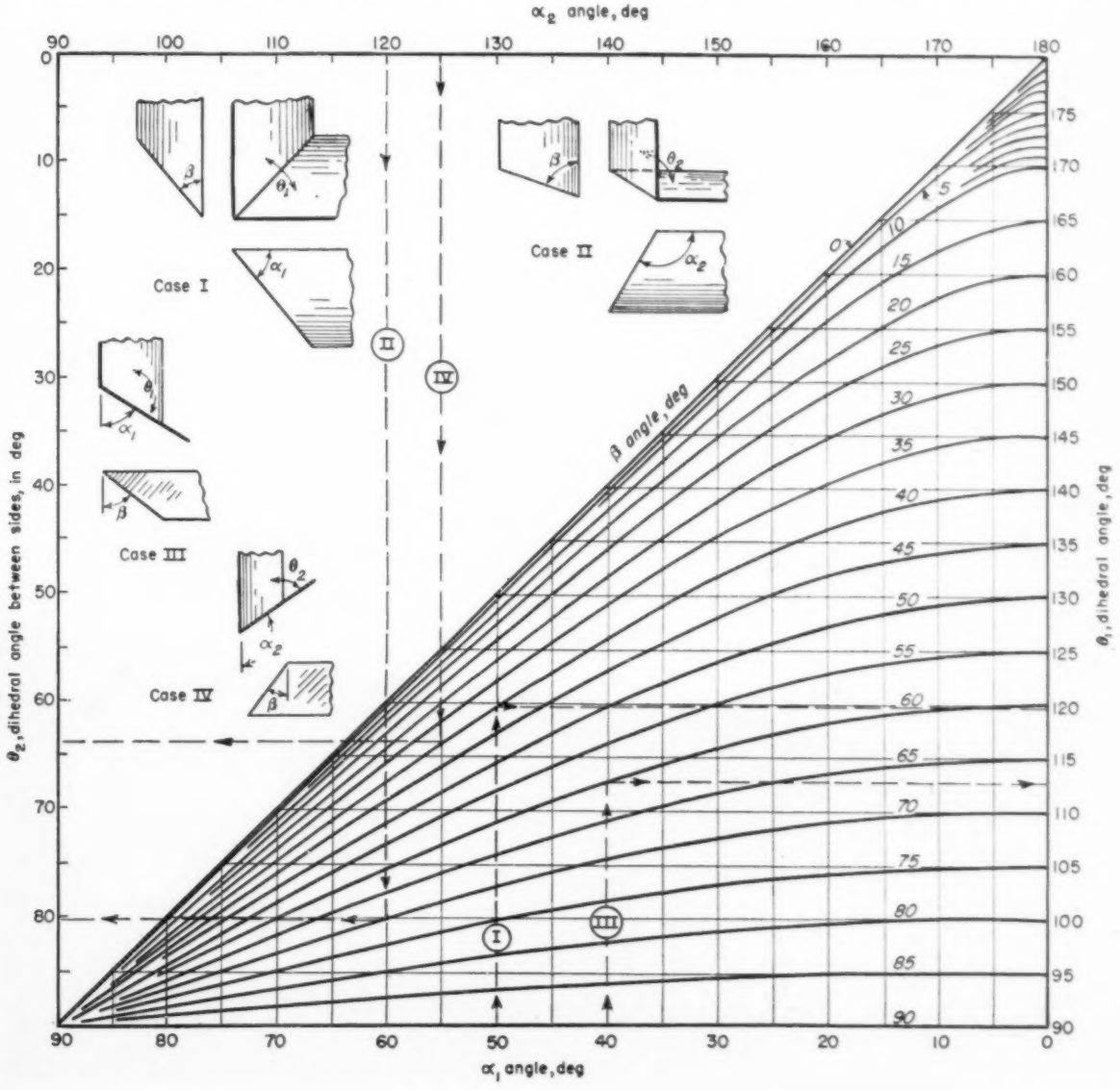
This chart has been arranged to include four types of corners. Although Case I is most common, the other types are occasionally encountered. Note the double scales; this arrangement permits the use of angles (α and θ) up to 180 deg. When α_1 is less than 90 deg., the θ_1 scale should be used, with larger angles, α_2 and θ_2 scales apply.

EXAMPLES: Case I, right angle corner with both sides sloping inward at $\alpha_1 = 50°$ and $\beta = 40°$: projecting line I upward and to the right, $\theta_1 = 119° - 30'$.

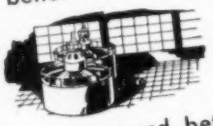
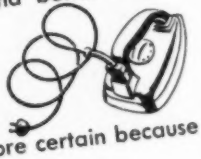
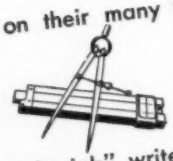
Case II, a right angle corner with one side sloping inward ($\beta = 70°$) while the other slopes outward ($\alpha_2 = 120°$). By projecting line II downward and to the left scale, $\theta_2 = 80° - 30'$.

Case III; with this corner, $\alpha_1 = 40°$ and $\beta = 60°$ (note one side is vertical); line III determines $\theta_1 = 112° - 30'$.

Case IV, joining at an acute angle and sides at: $\alpha_2 = 125°$ and $\beta = 40°$, the dihedral angle is found, $\theta = 64°$.



The right wire for the right job...

Technological advances in many industries constantly require new developments and new applications of wire and cable. A space-saving wire design has made possible smaller, more compact motors. A new and better form of heat resistance in turn prevents failure in generators.  Again, if a sharp turn can be given a wire, a new and better clock may be possible. New abrasion characteristics  may mean milady's iron won't fail. A city's safety is made more certain because a solenoid sets new records in performance. As simple a thing as better shielding in a wiring harness can be the secret of clearer radio and television reception. Auto-Lite Engineers, drawing on their many years of automotive experience, can answer such problems.  For more complete information on the "right wire for the right job" write on your company letterhead to

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Helical Gear Design Chart

For 90° shaft angle

WAYNE A. RING
Barber-Colman Company

IN PRELIMINARY LAYOUT WORK of gear drives, it is important to find whether the diametral pitch, gear ratio, and center distance, are possible. With this settled, the designer can proceed to calculate the specific helix angle.

This chart serves both purposes. For, if the Factor $2CP_n/N$ does not intersect the proper ratio curve R, this combination is not satisfactory. Also, in choosing the helix angle, a large amount of trial and error work is eliminated by this graph which gives a good approximation. In addition to helical gears, worm gear designs can be simplified with this chart. For helical gears with parallel shafts, a nomograph was published in PRODUCT ENGINEERING, p 159, Nov. 1949.

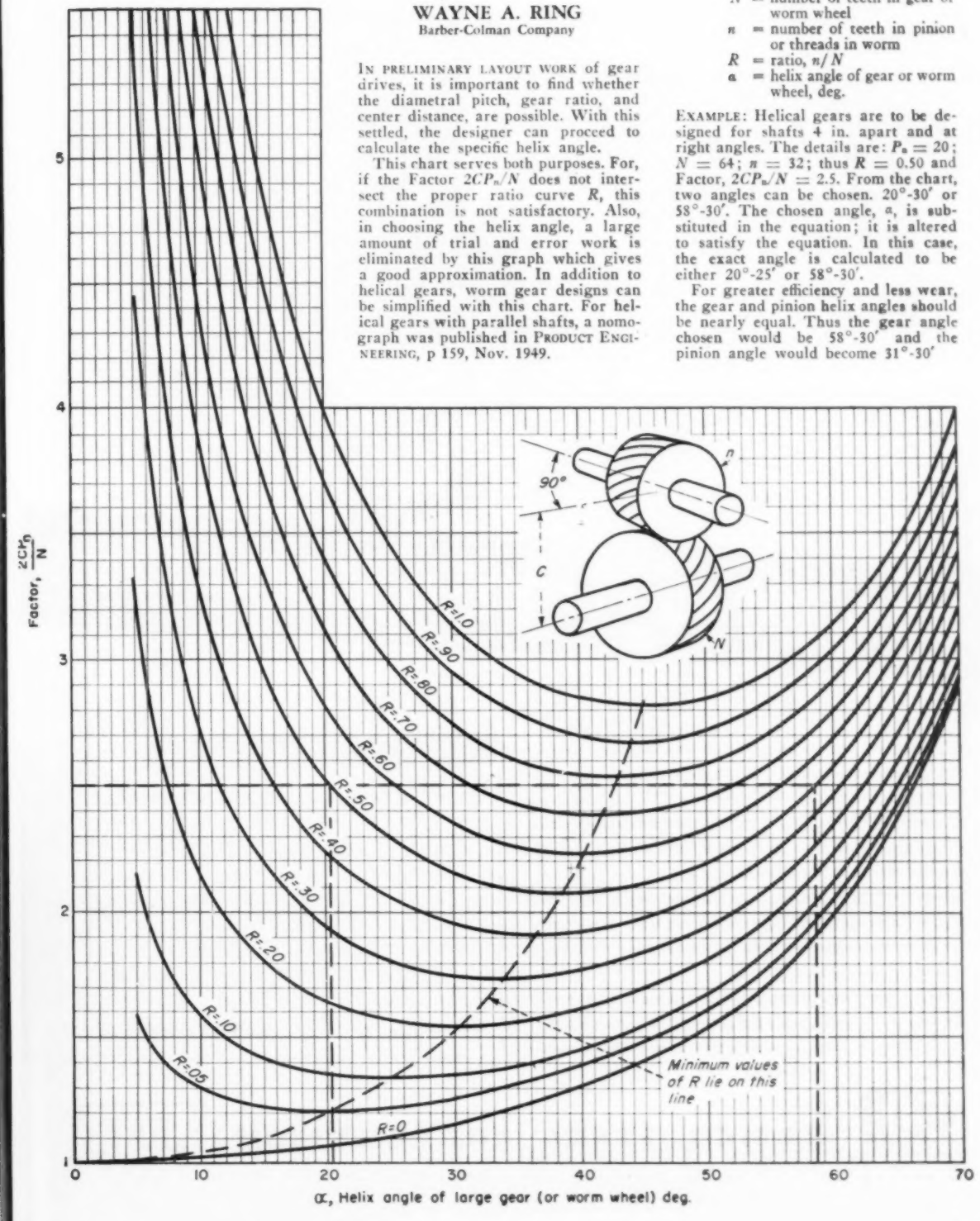
This graph is based on the equation:

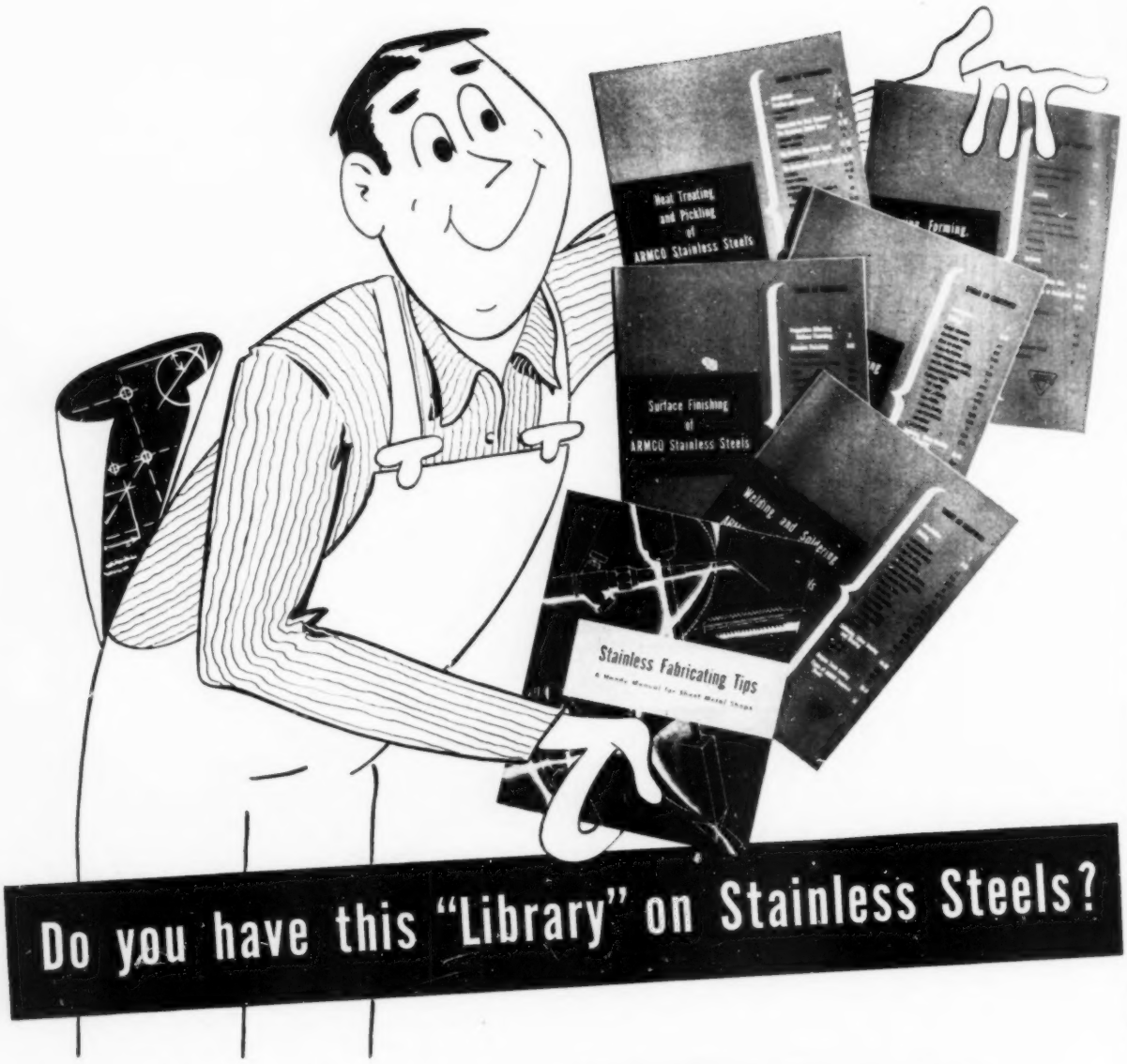
$$\frac{2CP_n}{N} = \frac{R}{\sin \alpha} + \frac{1}{\cos \alpha}$$

where: C = center distance, in.
P_n = normal diametral pitch
N = number of teeth in gear or worm wheel
n = number of teeth in pinion or threads in worm
R = ratio, n/N
α = helix angle of gear or worm wheel, deg.

EXAMPLE: Helical gears are to be designed for shafts 4 in. apart and at right angles. The details are: $P_n = 20$; $N = 64$; $n = 32$; thus $R = 0.50$ and Factor, $2CP_n/N = 2.5$. From the chart, two angles can be chosen. 20°-30′ or 58°-30′. The chosen angle, α, is substituted in the equation; it is altered to satisfy the equation. In this case, the exact angle is calculated to be either 20°-25′ or 58°-30′.

For greater efficiency and less wear, the gear and pinion helix angles should be nearly equal. Thus the gear angle chosen would be 58°-30′ and the pinion angle would become 31°-30′

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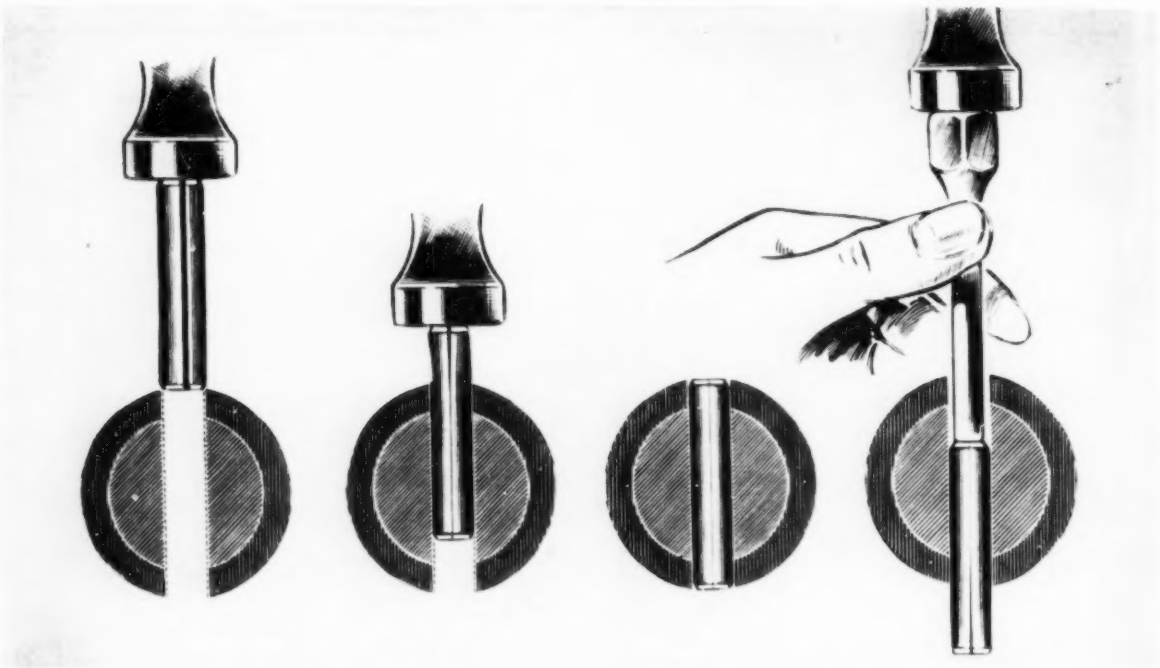
N. S. MOTT
Chief Chemist & Metallurgist, The Cooper Alloy Foundry Co.

Alloy Type	Percent Nom. Chemical Composition						Designation					Basic Uses[7]
	C	Cr	Ni	Si	Mo	Other	ACI[2]	AISI[3]	SAE[4]	ASTM[2]	Other[2]	
5 Cr	0.20	5	0.5	0.75	0.5			501		A157-46 Grade C5A		C-H
8 Cr	0.20	8.5	0.5	0.75	1.25					A157-44 Grade C12		C-H
12Cr	0.12	12.5	0.5	0.75			CA-15	410	60410	A296-49T Grade CA-15 A157-44 Grade C6 A221-39 Class A	USN 46S12E Hydraulic Inst. #0	C-H
12 Cr-HC	0.30	12.5	0.5	0.75			CA-40	420	60420			A-C-E
12-2	0.12	12.5	2	0.75				414	51414			C
12 FM	0.12	12.5	0.5	0.75	0.5	(5)		416	51416-F			C
16 Cr	0.10	16	0.5	0.5				430	51430			C
16 FM	0.10	16	0.5	0.5	0.5	(5)						C
18 Cr	0.25	18	0.5	0.5			CB-30	442	60442	A296-49T Grade CB-30 A221-39 Class B	Hydraulic Inst. #1	C-H
18 Cr-HC	0.60	18	0.5	0.5				440A	51440A			A-C-E
18 Cr-HC	0.80	18	0.5	0.5				440B	51440B			A-C-E
18 Cr-HC	1.00	18	0.5	0.5				440C	51440C			A-C-E
18-2	0.25	18	2	0.5				441				C
21 Cr	0.25	21	0.5	0.5			CB-30	442	60442	A296-49T Grade CB-30	Hydraulic Inst. #1	C-H
21 Cr-Cu	0.25	21	0.5	0.5		Cu 1		443		A221-39 Class B	Carpenter #3	C
28 Cr	0.30	28	0.5	0.5			CC-50	446	60446	A296-49T Grade CB-30	Hydraulic Inst. #2	H-C
							HC		70446	A297-49T Grade HC		
										A221-39 Class C		A-C-E-H
28 Cr-HC	2.5	28	3	0.5								C-H
28-3	0.30	28	3	0.5			CC-50	446	60446	A296-49T Grade CB-30	Hydraulic Inst. #2	
							HC		70446	A297-49T Grade HC		H
							HD		70327			
28-6	0.30	28	6	0.5								C-E
28-3 Mo	0.10	28	3	0.5	1.5		CD-10M	329				
18-8 S	0.07	19	9	1.25			CF-8	304	60304	A296-49T Grade CF-8 A198-39 Grade A	Hydraulic Inst. #3	C
18-8 S-Cb	0.07	19	9	1.25		(6)	CF-8C	347	60347	A296-49T Grade CF-8C	Hydraulic Inst. #3	C
18-8 S-Mo[5]	0.07	19	9	1.25	2.5		CF-8M	316	60316	A296-49T Grade CF-8M A198-39 Grade A	KA2SMo Hydraulic Inst. #4	C
18-8	0.15	19	9	1.25			CF-20	302	30302	A296-49T Grade CF-20 A157-44 Grade C9 A198-39 Grade B	KA2	C-H
18-8FM	0.15	19	9	1.25	<1.5	(5)	CF-16F	303	60303	A296-49T Grade CF-16 Fa A157-44 Grade C9 (Se)		C
18-8 Mo	0.10	19	9	1.25	2.5		CF-12M			A296-49T Grade CF-12M A157-44 Grade C9 (Mo)	KA4	C
18-8 HC	0.30	19	9	1.50	<0.5		HF		70308	A297-49T Grade HF		H
20-10	0.10	20.5	10.5	1.25			CG-12	308		A296-49T Grade CG-12	USN 46S27	C
9-20	0.20	9	21	1.25			CM-25	325	30325	A223-39 Class A A157-44 Grade C10		C-H
20-25	0.07	20	25	1.25			CN-7	311				C
20-25 Mo	0.07	20	25	1.25	2		CN-7M					C
20-25 Mo-Cu	0.07	20	25	1.25	3	Cu 1	CN-7M Cu				Durimet "T"; Worthite; Hyd. Inst. #5	C
20-25 Mo-Cu	0.07	20	25	3.25	3	Cu 2	CN-7M Cu				Durimet "20"; Dupont FA20	C
20-29 Mo-Cu	0.07	20	29	1.25	3.5	Cu 4	CN-7M Cu				Hydraulic Inst. #5	
25-12 S	0.07	25	12	1.25			CH-10	309S		A296-49T Grade CH-10 A222-39 Class A		C
25-12 S-Cb	0.07	25	12	1.25		(6)	CH-10C					C
25-12 S-Mo	0.07	25	12	1.25	2.5		CH-10M					C
25-12	0.15	25	12	1.25			CH-20	309	60309	A296-49T Grade CH-20		C
25-12 Mo	0.15	25	12	1.25	2.5		CH-20M					C
25-12	0.30	25	12	1.5	<0.5		HH		70309	A297-49T Grade HH A222-39 Class A B190-45T Type I or II		H
29-9 S	0.20	29	9	1.5			CE-30	312	60312	A296-49T Grade CE-30 A222-39 Class C		C
29-9	0.30	29	9	1.5	<0.5		HE			A297-49T Grade HE		H
28-16	0.30	28	16	1.5	<0.5		HI			A297-49T Grade HI		H
25-20 S	0.07	25	20	1.25			CK-20	310	60310	A296-49T Grade CK-20 A222-39 Class B		C
25-20 S-Cb	0.07	25	20	1.25			CK-20C					C
25-20 Mo-Cu	0.07	25	20	1.25	2	Cu 3						C
25-20	0.30	25	20	1.5	<0.5		HK		70310	A297-49T Grade HK	USN 46S49	H
30-20	0.50	30	20	1.5	<0.5		HL		70310A			H
15-35 S	0.07	15	35	1.25			CT-7	330		A223-39 Class B		C
15-35 Mo-Cu	0.07	15	35	1.25	3.5	Cu 2	CT-7M Cu					C
15-35	0.40	15	35	1.5	<0.5		HT		70330	A297-49T Grade HT B207-46T		H
18-38	0.40	18	38	1.5	<0.5		HU		70331	A297-49T Grade HU		H
12-60	0.40	12	60	1.5	<0.5		HW		70334	A297-49T Grade HW		H
17-66	0.40	17	66	1.5	<0.5		HX		70335	A297-49T Grade HX		H
14-78	0.08	14	78	1		Fe 6					Inconel	C-H
20-80	0.08	19	79	1		Fe 0.5					Nichrome V	C-H

Notes:
[1] Common practice is to use wrought designations for castings. This is not recommended, and should be used only when cast designation is lacking.
[2] Cast alloy designation
[3] Wrought alloy designation
[4] 51,000 and 30,000 series are wrought designations.
[5] AISI Type 317 contains 3.5 percent Mo
[6] Columbium = 8 x C; 1 percent max.
[7] A, abrasion resistance
C, Corrosion resistance
E, Erosion-corrosion resistance
H, Heat resistance
[8] S or Se 0.25 percent

DESIGN DETAILS AND DATA ON

NEW COMPONENTS—



Expanding Tube Grips Sides of Undersize Hole

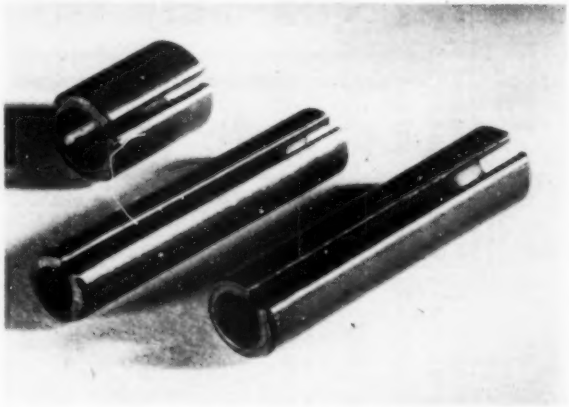
Used as instrument shaft, dowel pin, cotter pin and pivot pin.

A Luftwaffe airplane cannon, captured in 1942, yielded the secret of the expanding pin. It is essentially a metal cylinder with a longitudinal slot. The cylinder is chamfered at both ends and can be driven into a hole smaller than its own original outside diameter. To fit the hole, the cylinder is compressed, taking up the slot distance in its circumference. Shear strength is claimed to exceed that of a cold-rolled pin of equal diameter.

The pin is self locking within normal production hole tolerances. The hole does not have to be brought to exact size by reaming and burnishing. The pin does not extend beyond its hole and no extra external locking devices are necessary.

The expanding pin is a self-positioning shaft, when used in gear trains. Its grip in the gears makes it possible to adjust each gear to its specific location. There are, of course, limitations to the torque that can be carried. The allowable torque increases in direct proportion to the pin diameter and the length of the hub.

Standard pins are SAE 1095 or stainless steel. Plated or beryllium copper pins can be made. Standard diameters fit 13 hole sizes from 5/64 to $\frac{1}{2}$ inch. Other sizes and alloys can be supplied on production orders.

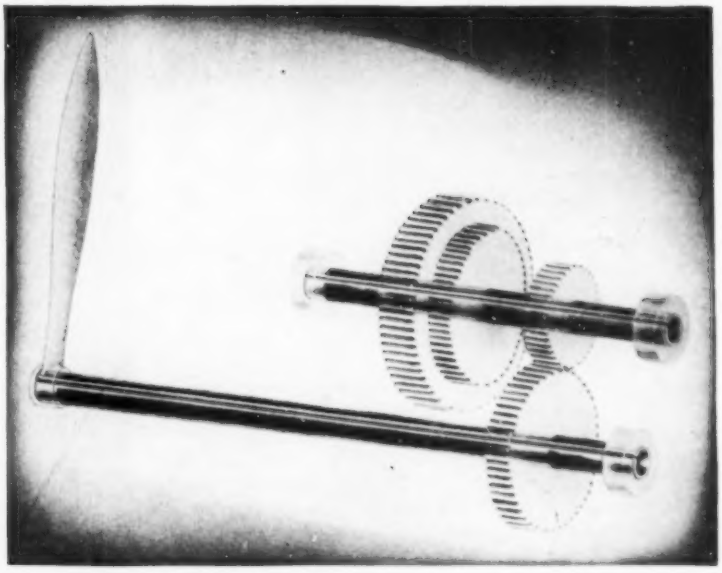


CHAMFERED ENDS allow the pin to be driven and compressed into a hole that is smaller than the outside diameter of the pin. Rapid insertion is possible with hand tools or automatic jigs. As shown above, the pin can be taken out as quickly and simply as it is put in. There are no set screws to be taken out or taper keys to catch and pull out. Pins can be reused.

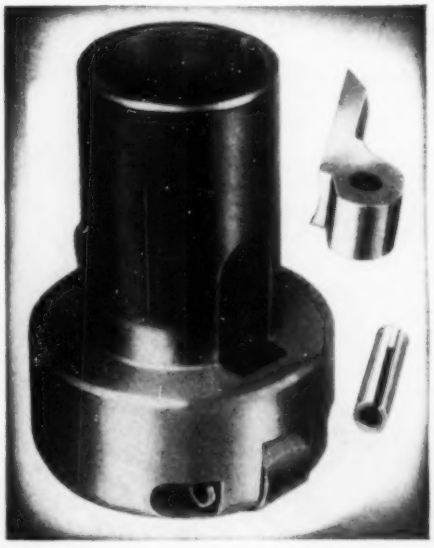
MATERIALS AND PARTS

SPECIFIED BY PRODUCT ENGINEERS

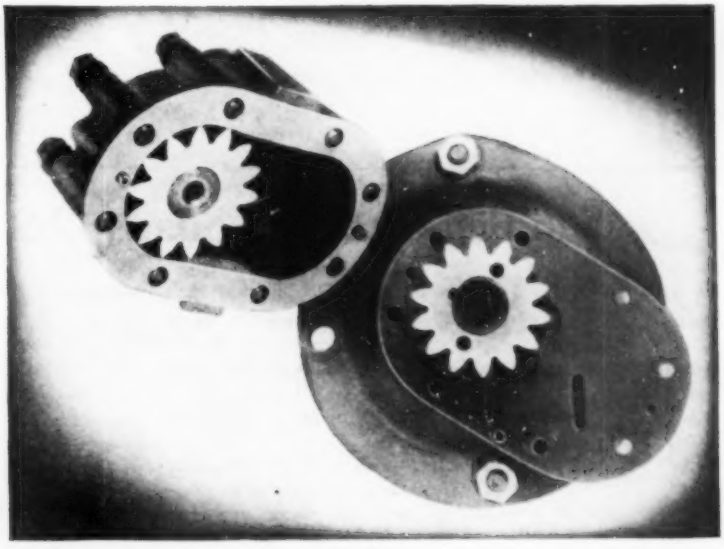
AUTOMOBILE WINDOW CATCH is held on its shaft by the expansion pin. The usual catch is pinned by a tapered or grooved pin. These tend to wear loose with hard use.



GEAR TRAIN ASSEMBLY SHAFTS are another application. The small parts are secured in place in one operation by a jig assembly. Splines, set screws, and, key ways are not needed. On plastic gears especially these extra fasteners have proved troublesome and expensive. The expanding pin cuts production costs.



EXPANSION PIN holds actuating finger in machine assembly. A hardened, ground tapered pin was replaced here. Easier assembly is provided, since the parts do not have to be line-reamed with a taper reamer. The new pin withstands 2,400 stress reversals per hour.



PUMP ASSEMBLY is an example of applications as positioning dowels. A pin can be re-used, retaining adequate tension under load. As the dowel holes wear, the pin expands to keep a tight fit, without additional reaming and a new pin. Since hub shoulders for set screws are not needed, space is saved in pump housings. There are no keyways to machine in pump impellers or shafts.

Elastic Stop Nut Corp., 2330 Vauxhall Rd., Union, N. J.

Circle No. 1 on Reader Service Card

CONTINUED ON PAGE 166

Bearing Temperatures Are Read Remotely

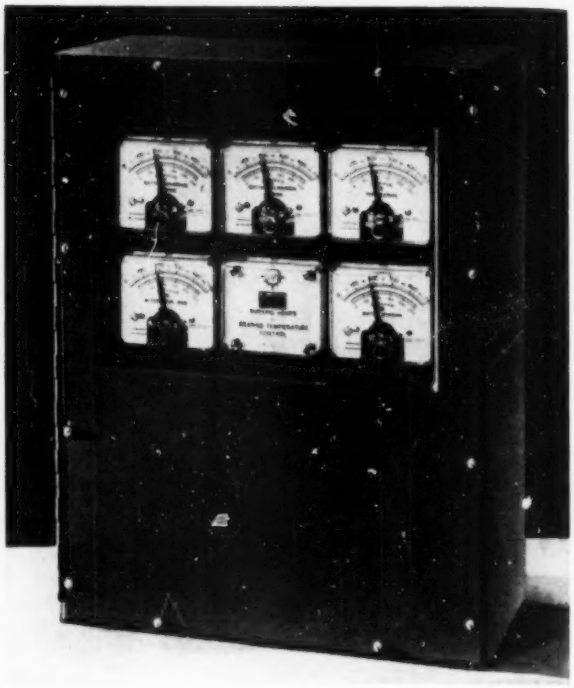
Multiple meter controls give remote indication of bearing temperatures. They provide an alarm or machine shut-down in case of over-heating. Corrective factors may be applied automatically.

A separate meter, with thermocouple, is used for each bearing or other point to be monitored. Any number of bearings may be protected. The meters are calibrated in degrees of temperature, both Centigrade and Farenheit. Contacts close on temperature rise, or, on closed circuit controls, contacts open on temperature rise. The meter contacts operate the load relays directly with contacts rated at 15 amp, 115 v, or 7½ amp, 230 v. The relay may ring an alarm, close down a machine or automatically apply a correction to overcome the cause of over-heating.

The control unit consists of a metal cabinet with hinged front panel on which all components are mounted. These consist of a transformer, rectifier power supply for the relays, the load relay and other equipment. The control may be mounted at a distance from the machine. No mechanical linkage is used; all connections are electrical. The cabinet has knockouts for conduit on four sides, and surface and flush panel mounting units are available.

Both open and closed circuit types are made. In the closed circuit control, low limit contact meters are used. During normal operation the meter contacts remain closed. A rise in temperature opens the contacts, allowing the load relay to drop out. In the open circuit control, high limit meters are used. These are normally open. A rise in temperature closes the contacts and the load relays pull in. This may apply corrective measures.

The unit illustrated has five control meters. The sixth meter indicates running time in hours. These multiple meter controls may be used to measure and control temperature at several points simultaneously. The relays may control individual heating or cooling elements, or they may be used together to operate a common alarm.



Several furnaces or ovens may be controlled, even though different temperatures are required in each. Other applications include diesel exhaust temperatures, chemical processes, plastic and rubber molding machines.

Assembly Products, Inc., Chagrin Falls, Ohio

Circle No. 2 on Reader Service Card

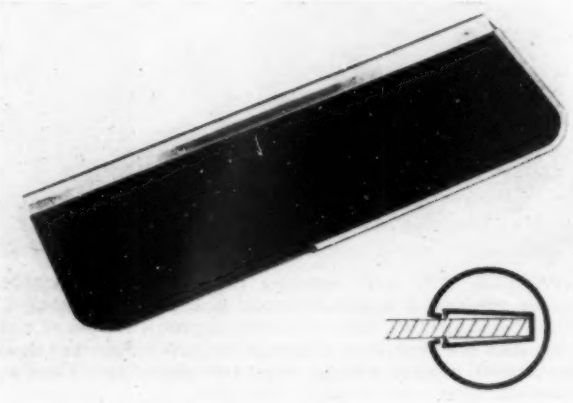
Stainless Beading Snaps On Exposed Edge

A bright, stainless, snap-on beading has been developed for dressing-up raw edges on plastics, woods, leather, metal and other materials.

Installation is claimed to be extremely easy. A hand tool is used for applying small toothed clips at intervals along the edge. The moulding snaps over, completely concealing the clips.

This trim is being made available in ⅜ in. diameter for edges 0.100 in. thick, with other sizes to follow. The edge can be applied to products of any size, shape or material and will add to the styling and strength without running the cost up excessively, according to the manufacturer. The new edge can be formed in any shape.

Extensive research has been conducted with the new edging material with regard to the best methods of attachment.

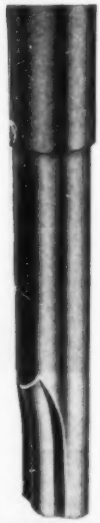


Spotrim Corp., 15301 Mack Ave., Detroit 24, Mich.

Circle No. 3 on Reader Service Card

CONTINUED ON PAGE 168

TYPE "A" ASSEMBLY BIT



COMMON SCREWDRIVER

CLUTCH HEAD *Invites Comparison With* ALL *Other Screws...*

. . . RECESSED HEADS AS WELL AS SLOTTED

It is generally conceded that recessed head screws have outmoded the use of slotted head screws on modern assembly lines. For that reason, CLUTCH HEAD user quotations . . . recording production increases ranging from 15% to 50% . . . are based on comparison with *other types of recessed head screws.*

Only Clutch Head provides Center-Pivot entry for safe automatic straight driving.
Only Clutch Head has non-tapered driving to eliminate the skid hazard of "ride-out."
Only Clutch Head offers this all-square driving contact as a safety factor.
Only Clutch Head eliminates the fatigue of end pressure for easier, faster driving.
Only Clutch Head has the Lock-On which permits one-handed driving from any angle.
Only Clutch Head delivers Bit durability that drives up to 214,000 screws, non-stop.
Only Clutch Head has a recess basically designed for common screwdriver operation.

America's Most Modern Screw invites you to make your own comparison . . . to evaluate these exclusive CLUTCH HEAD features...right

CLUTCH HEAD SCREWS

at your own desk. Your request will bring you, by mail, package assortment of screws, sample Type "A" Bit, and Illustrated Brochure.

UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7

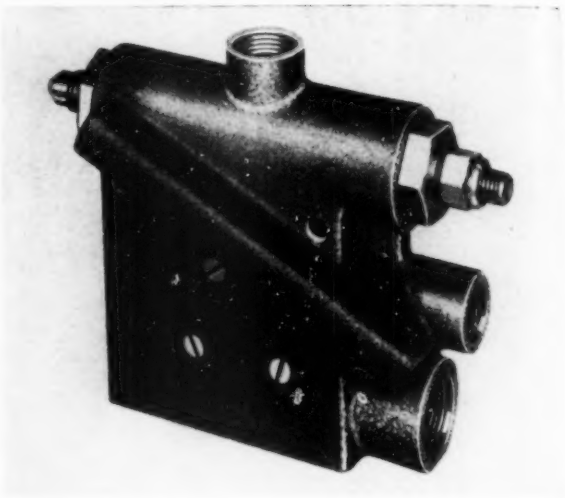
Relief Valve Adjusts To Wide Range of Pressures

A cartridge type hydraulic relief valve meets or exceeds Government standards as set up by Specification AN-V-lb for Army and Navy aeronautical use. Available for pressure settings ranging from 100 to 5,000 psi, the valve opens and closes within a 7 percent differential. Even smaller operating differentials can be had for special applications. Constant repeat accuracy is claimed with the "in balance" design. This balance is not disturbed by load shocks or surges.

Valve is silent and free from squeal and chatter. The design eliminates wire drawing and provides high volume flow at all pressures. It has been tested through temperature variations ranging from —65 F to +160 F with no more than a 5 percent change in operating characteristics.

The entire operating mechanism is contained in a cartridge which may be replaced without breaking the line. Pressure adjustments are made by an accessible screw. Housings are ported for $\frac{3}{8}$, $\frac{1}{2}$ and $\frac{3}{4}$ in. pipe. Applications are expected in airplane hydraulic pressure systems.

Hydraulics Div., Pantex Mfg. Corp., Pawtucket, R. I.



Circle No. 4 on Reader Service Card

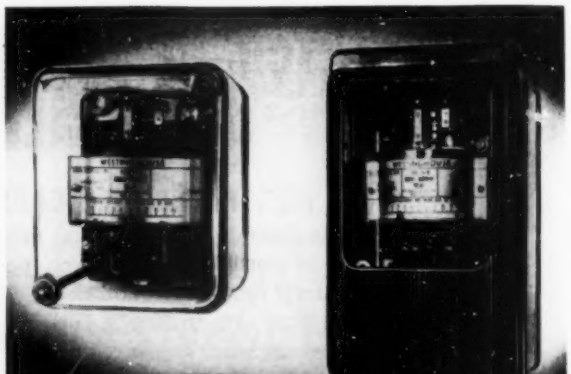
Relays Give Current and Temperature Protection

Two relays are offered to supersede the manufacturer's previous types for current and temperature protection. The first relay is for service in dc circuits to furnish protection against over-current, under current and reverse current. The operating voltage is supplied by a shunt in series with the protected line. The moving coil is in parallel with the shunt so it will receive current in proportion to line current.

The second type relay is for protection of transformers, ac or dc motors and generators from damage from abnormally high temperatures. An exploring coil in the windings of the protected apparatus forms one leg of a resistance bridge which supplies energy for the relay.

Both relays have single-pole, double-throw contacts. A permanent magnet core within the moving coil supplies a constant field and cuts the size of the relay approximately in half in comparison to its predecessor.

Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.



Circle No. 5 on Reader Service Card

Black Finish Resists Corrosion, Holds Dimensions

A metal coloring process gives a rust-resistant finish to metal stampings, screw machine parts, wire products, springs and castings. Dimensions are not changed. Parts previously heat-treated to 300 F are uneffected. Low electrical resistance of the finish prevents flashing in welding. Approximately 250 sq ft are covered per lb of dry powder.

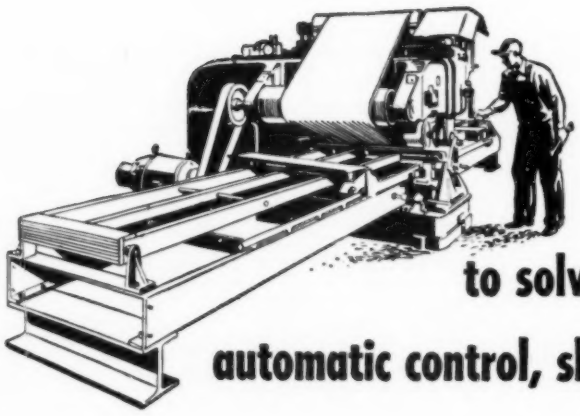
A good undercoat for laquers and enamels is provided. No baking or accelerated drying is required. The coating mixture is made by adding 7¼ lb of powder to each gallon of water. Parts are dipped with the solution at a rolling boil. The solution will not deteriorate and can cool over week-ends.

The black surface is rough enough to hold organic finishes that may be put on for appearance or corrosion protection.

Atomite Black Co., 549 Washington Blvd., Chicago 6, Ill.

Circle No. 6 on Reader Service Card

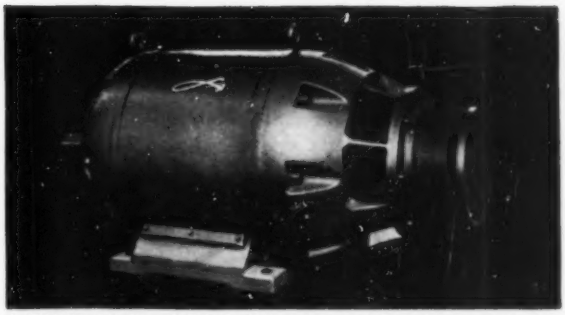
CONTINUED ON PAGE 170



Smart design engineers use WARNER ICB UNITS to solve problems of clutching, braking, automatic control, shock and torque on their products

IF YOUR PROBLEM

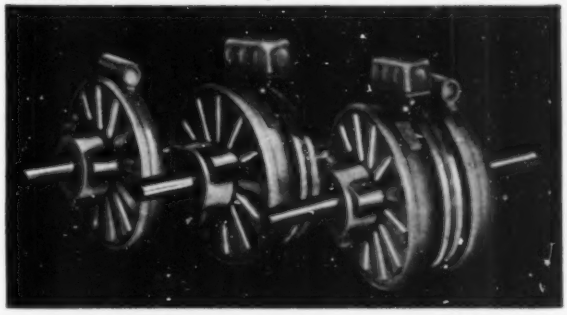
is to design your machine or its activating parts so that *you get:* (1) Push-button actuation at the machine or a remote control panel. (2) Fully or semi-automatic operation in "stop" or "start" of machine cycles. (3) Controlled acceleration or deceleration. (4) Automatic or manual adjustment of torque to load . . . or if your problem is *to eliminate:* (1) "Shock" from stop or start on gear trains and shafts. (2) Complex mechanical lever linkage, or air and hydraulic piping systems. (3) Vibration and hammering from solenoid operated brakes and clutches . . . or if you want to *increase production* from your machine by increasing the speed and number of cycle operations —



A WARNER ICB 9" x 2½" Brake Unit installed and housed on a standard 40 hp motor for a flat belt sander. Installation speeded up machine cycling, gave better, faster operational control. Installation is simple, compact and readily accessible.

A GOOD SOLUTION

to any one or combination of these problems is WARNER ICB Units. WARNER ICB Units are electrically controlled and operated clutches and brakes. They are compact, mechanically simple and may be applied to machine spindles, drive shafts, or direct to electric motors. Because of their design, they may be operated individually or in combination, manually or automatically, by direct or remote control. They provide for infinite controlled variation of torque in either clutching or braking action within their rated capacities. Their action is smooth and shockless—fast and practically noiseless. They are self-adjusting and self-compensating for life. Their design guarantees a high rate of heat dissipation.



From left to right: a Warner ICB Brake Unit, a Warner ICB Clutch Unit, and a combination Warner ICB Clutch and Brake Unit. Note clean, smooth, compact, appearance — simple mechanical parts.

MORE INFORMATION

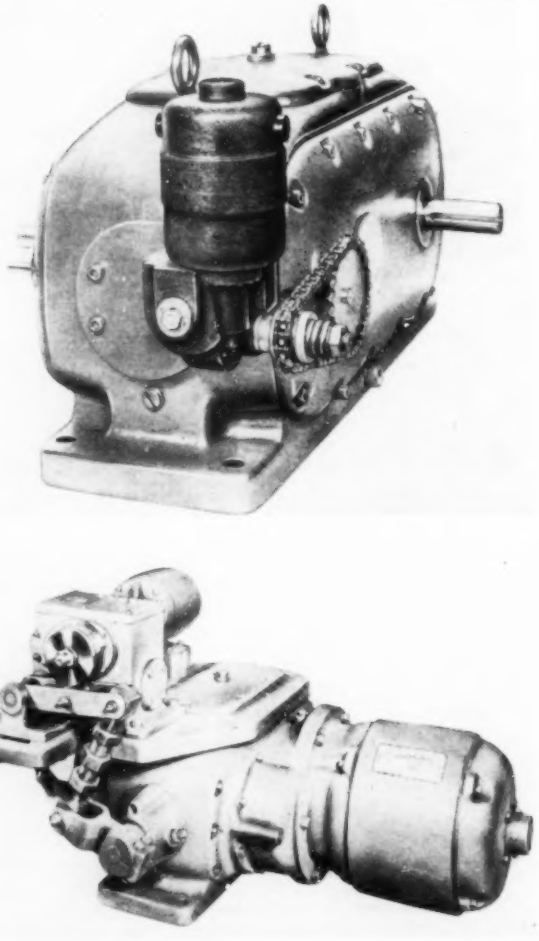
on WARNER ICB Units and their application as clutches or brakes to various kinds of machinery is available. They may be used on continuous or intermittently operated machines. There is a complete range of sizes to meet both braking and clutching torque needs. If you have a design problem such as indicated above, write today for our free bulletin No. 701. If possible, state your problem. Not only will you receive your bulletin copy, but experienced WARNER ICB engineers will be glad to consult with you without obligation. Write direct to WARNER ELECTRIC BRAKE MANUFACTURING COMPANY, Beloit, Wis.

Bulletin 701 contains complete specifications and description of WARNER ICB Units. See for yourself how they offer advantages never before available on industrial clutches and brakes. Write for it today — no charge.

WARNER
ICB UNIT

WARNER ICB Units are manufactured by Warner Electric Brake Mfg. Co. — pioneers in the field of electric brake design and application since 1927.

Automatic Systems Control Variable-Speed Drive



Electronic, pneumatic, hydraulic and mechanical control systems are built into a standard variable-speed drive. Output speed will follow any external condition, adjusting itself in a predetermined manner. A floating roll can maintain constant tension in a winding operation.

The electronic system is used when control point is separated from drive. Two potentiometers are connected in a bridge. Movement of one potentiometer actuates the small control motor. The other potentiometer rotates with the control screw and permits the system to change speed until the bridge circuit is again in balance.

The pneumatic control fits into existing plant air systems and is explosion-proof. Speed is varied by cylinder piston movement. Output speed depends on piston position, which is directly dependent on air pressure.

The hydraulic system is suitable where extreme sensitivity, highly accurate control or rapid response is necessary. The position of the hydraulic cylinder piston determines output of the variable speed drive. The cylinder is governed by a hydraulic valve. A very small arc of valve movement will actuate the cylinder and change speed.

Mechanical control is best where sufficient operating force is available to permit direct connection through a simple linkage system. A motor driven cam and follower for a set speed cycle is illustrated. The cam follower varies speed. The cycle depends on control motor speed and cam contour.

The variable speed transmission is available in 8 sizes, from 1 to 25 hp, for ratios to 6:1, in 16 standard types, including plain, motorized, single and double reduction geared units, for horizontal or vertical mounting.

Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill.

Circle No. 7 on Reader Service Card

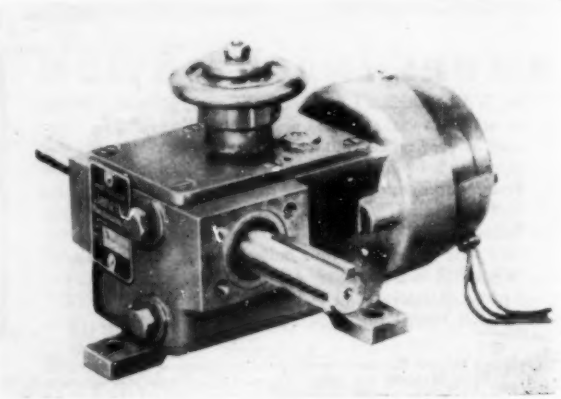
Double Worm Gear Gives Low Output Speed

A two-shaft gear motor gives very slow speeds on twin output shafts. Developed for combustion control systems, the gear motor uses double-reduction worm gearing to furnish an output speed of 0.4006 rpm and approximately 220 in-lb output torque. Speed reduction is 4242.4 to 1.

The drive is a special single-phase, 60 cycle, 115 volt, 1725 rpm capacitor-run, capacitor-start motor, furnished with 3 leads. It is reversible up to 20 times per minute.

A double output shaft is provided, at right angles to the input shaft. One side of this shaft is designed to drive a limit switch. A 2½ in. handwheel operates a clutch, disconnecting the motor from the first reduction worm gear. The output shaft can then be turned by the handwheel.

Weighing about 12 pounds, the motor-reducer measures 8⅝ in. in length, 9 3/16 in. in width, and stands 5 1/32 in. high.



Janette Mfg. Co., 555 W. Munroe St., Chicago, Ill.

Circle No. 8 on Reader Service Card

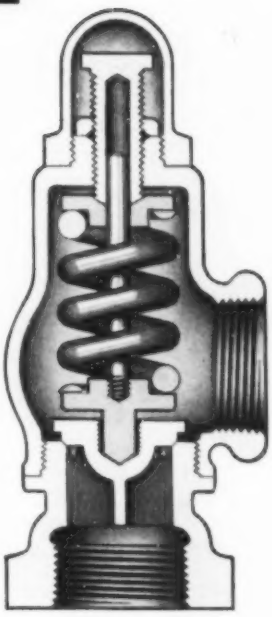
CONTINUED ON PAGE 172

To save time on every design ...Specify piping from CRANE

Whether your design job calls for a lot of piping—as on this *Steam Generator*—or for very little, you can't help but save specifying time when you reach for your Crane Catalog. Why? Because it not only contains the world's most complete line of piping equipment, but lists it so you can find every item you need . . . in a hurry.

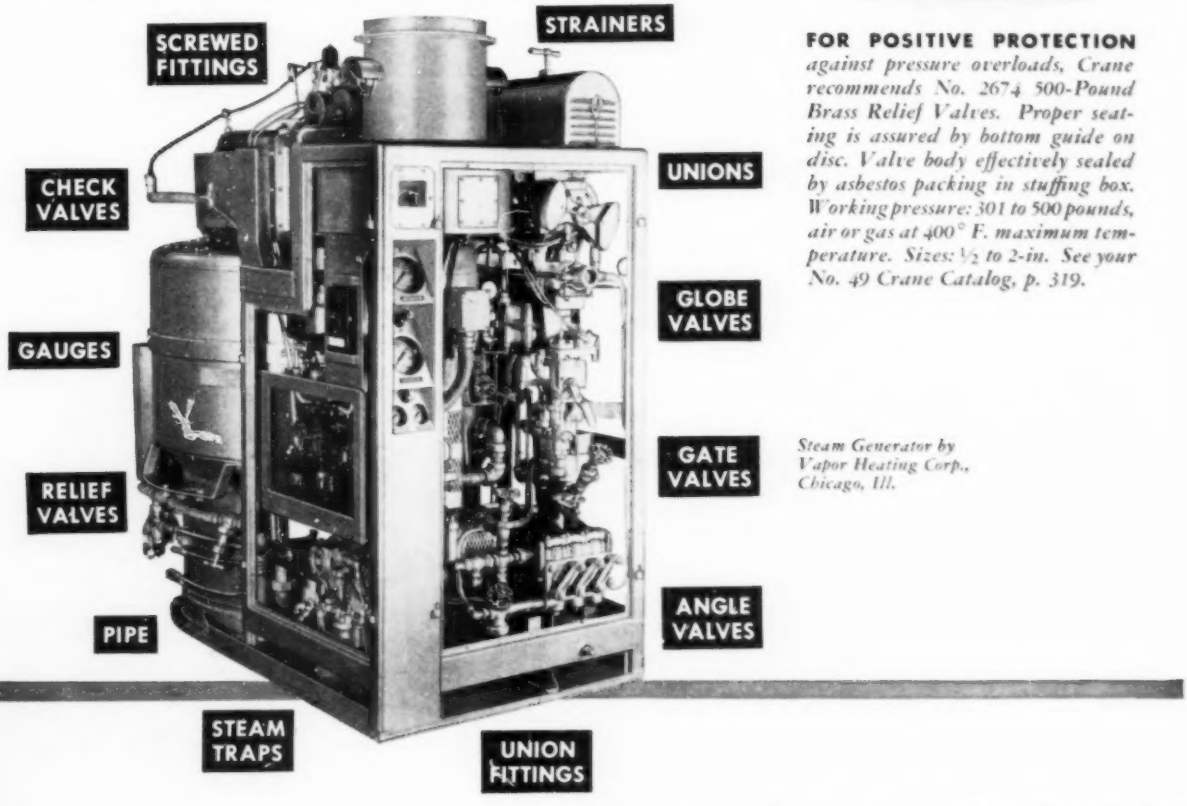
To be able to get *everything* from one supplier—as you can from Crane—simplifies all piping procedures, from original product design to final product assembly. In addition, your product acquires added value when it's Crane-equipped. For buyers know that Crane Quality stands for the best in piping materials.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas



FOR POSITIVE PROTECTION *against pressure overloads, Crane recommends No. 2674 500-Pound Brass Relief Valves. Proper seating is assured by bottom guide on disc. Valve body effectively sealed by asbestos packing in stuffing box. Working pressure: 301 to 500 pounds, air or gas at 400° F. maximum temperature. Sizes: ½ to 2-in. See your No. 49 Crane Catalog, p. 319.*

FOR A BIGGER SELECTION OF BETTER PIPING ... LOOK TO THE BIG CRANE LINE

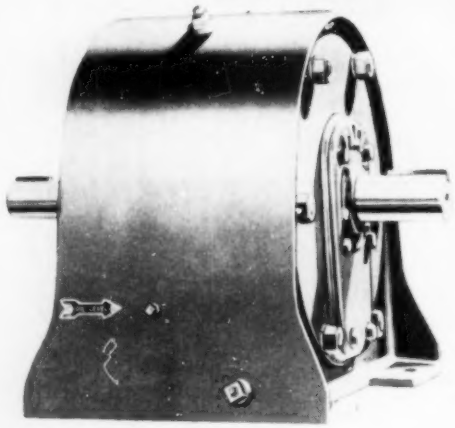


Steam Generator by Vapor Heating Corp., Chicago, Ill.

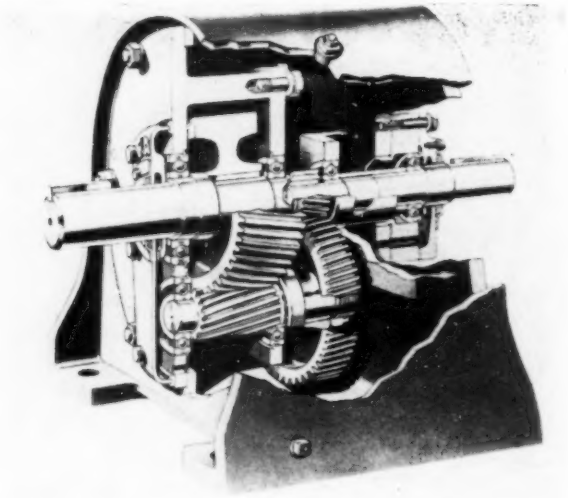
EVERYTHING FOR EVERY PIPING SYSTEM

CRANE

VALVES • FITTINGS • PIPE • PLUMBING AND HEATING



ALL-STEEL, SEALED HOUSINGS are stronger and more rigid than cast iron. One-way air vent at top keeps oil in, dust and moisture out. Weight is saved over cast iron enclosures.



EFFICIENCIES from 96 to 98.5 percent, at reductions from 1.5:1 to 970:1 are claimed with standard helical gears. Gears are taper bored to make ratio changes easy.

Steel Housings Protect Speed Reduction Gears

Heat treated, shaved gears run quietly at high mechanical efficiency.

Concentric-shaft and right-angle gear reducers are now in production for from 1 to 50 hp capacities. Straight roller, tapered roller and ball bearings are used on standard models. Steel housings have been used to give greater protection with lighter weight.

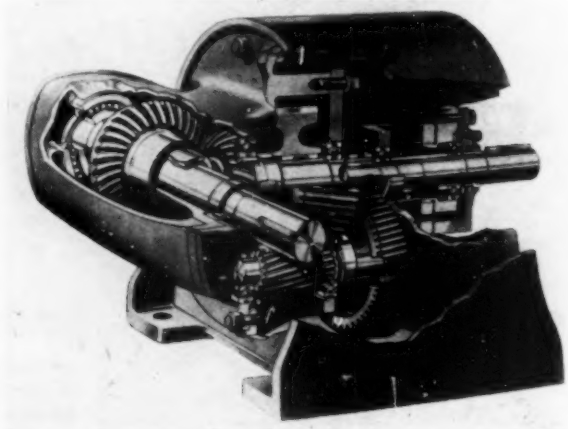
Single, double, triple and quadruple reduction units are available. Larger shafts and bearings, with wider bearing spacing than was standard in previous reducers have been used to give increased overhung load capacities. All ratings are for continuous 8 to 10 hours per day service. Oil-tight construction is designed to keep lubricant clean. Dip of revolving elements gives direct lubrication to gears and bearings. Rating overloads of 100 percent are allowed for starting. The units can also be used as speed increasers.

The single reduction ratio range is 1.49 to 6.15 to 1 in the parallel shaft units. Reductions from 3:35 to 969 to 1 are available in double, triple and quadruple reductions. Right angle reducer ranges cover 5.7 to 515 to 1 ratios.

Units are rated to standards of the American Gear Manufacturer's Association, and allow 100 percent starting and momentary overloads. Shafts and bearings have been designed heavy enough to take overhung loads from sprockets or pulleys. Internal backstops can be furnished with no changes to mounting dimensions. Gears are taper-bored so that gear changes can be made when different ratios are desired in standard units. Gear faces are heat treated and shaved for close fits.

The Falk Corp., Milwaukee 8, Wis.

	Concentric Shaft	Right Angle
Speed Range	Output 1 to 1170 rpm Imput up to 1750 rpm	Output 1 to 350 rpm Imput up to 1750 rpm
Efficiency	96 to 98.5 percent	96 to 98.5 percent Depends on Gear Trains
Ratio Range	Minimum 1.5 to 1 Maximum 970 to 1	Minimum 5.7 to 1 Maximum 515 to 1
Hp Range	1 to 50 Hp	1 to 50 Hp



RIGHT ANGLE REDUCERS, horizontal or vertical, with the same efficiencies and capacities are available in 5.7:1 to 515:1 ratios. Maximum input is 1750 rpm. Large bearings and wide bearing spacing improves capacity for overhung loads.

Circle No. 9 on Reader Service Card

CONTINUED ON PAGE 174

MAKE A TON OF SHEET STEEL GO FARTHER

Specify—

N-A-X

HIGH-TENSILE STEEL

SEVEN STRONG REASONS

There are seven excellent reasons why users of steel prefer – and specify—N-A-X HIGH-TENSILE steel. All of these reasons help manufacturers make a ton of sheet steel go farther.

- FINER GRAIN STRUCTURE
- GREAT IMPACT TOUGHNESS
- HIGH STRENGTH
- HIGH FATIGUE RESISTANCE
- GOOD FORMABILITY
- EXCELLENT WELDABILITY
- HIGH CORROSION RESISTANCE

GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division, Ecorse, Detroit 29, Michigan

NATIONAL STEEL CORPORATION

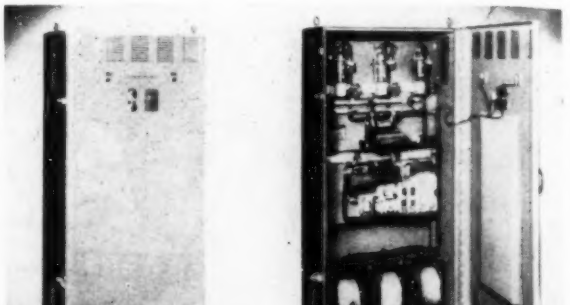
Electronic Rectifier Converts A-C to D-C

Floor- and wall-mounted electronic rectifiers convert a-c to d-c for general purpose industrial and commercial applications. Constant or adjustable d-c output voltages can be supplied with ratings as high as 230 v, 87 amp. On the adjustable voltage rectifiers the variable range is 60 to 100 percent of rated output.

All components, including the anode transformers, are mounted in factory assembled enclosures to simplify installation, inspection and maintenance. Electronic tubes and other components are rated conservatively for safety and increased operating life. Separate compensating adjustments for filament voltages are incorporated in all models.

The electronic rectifiers are designed for operation from 115/230 or 230/460 v, single phase or three phase.

Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.



Circle No. 10 on Reader Service Card

Miniature Chain Fits Extra Small Pulleys

A miniature load carrying chain and a stud chain specifically designed for use around very small pulleys and sprockets are now being manufactured. Made in either stainless steel or beryllium copper, the chains are non-magnetic and non-corrosive. The beryllium copper chain was developed for electronic applications requiring completely non-magnetic materials. Weighing 0.75 and 0.50 ounces per lineal foot, the chains give high strength, precision construction for miniature mechanisms.

The stud chain has applications in special cameras, facsimile equipment, electronic parts, special radios and small precision instruments. The load carrying chain was developed to operate around pulleys as small as $\frac{7}{16}$ in. in diameter, passing through a 180 deg turn without binding or slipping. It is especially useful in aircraft cockpit controls and other applications requiring smaller pulleys than those which handle standard $\frac{1}{16}$ in. cable. Chain end fittings can be supplied to specific requirements.

The load carrying chain using stainless steel links with heat treated SAE 4130 pins has a yield strength of 310 lb and an ultimate strength of 428 lb. In beryllium copper links with heat-treated SAE 4130 pins the yield strength is 290 lb, with an ultimate strength of 440 lb. The stud chain will operate around a seven tooth sprocket with a minimum diameter of 0.395 in. With stainless steel links, the stud chain has a yield strength of 100 lb and an ultimate strength of 170 lb. With beryllium copper links the stud chain has a yield strength of 80 lb and an ultimate strength of 140 lb.

Franklin C. Wolfe, Co., Inc., 407 Commercial Center St., Beverly Hills, Calif.

Circle No. 11 on Reader Service Card

Laboratory Instrument Covers Wide Range

An oscillosynchroscope is used in laboratories where versatility of oscillographic facilities is required. The vertical amplifier response is flat from five cycles to 16 megacycles. It extends beyond 30 megacycles, including the use of a 0.2 microsecond signal delay line. Two separate sweep systems permit accurate display of repetitive phenomena with recurrence rates as high as 10 megacycles, or transient and recurrent pulses as short as 0.05 microseconds.

Built-in trigger and delay generators are provided for synschroscopic applications such as those encountered in radar circuits. Time measurements are made by 0.1, 1.0, 10 and 100 microsecond timing markers.

Browning Laboratories, Inc., 750 Main St., Winchester, Mass.

Circle No. 12 on Reader Service Card

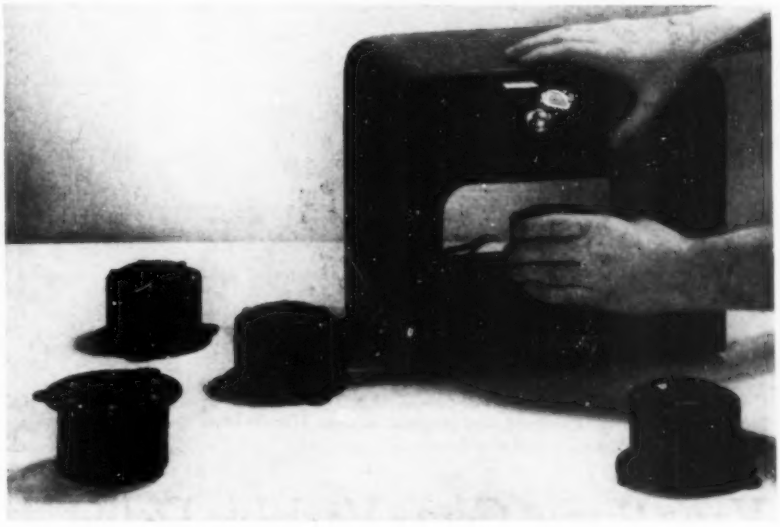
CONTINUED ON PAGE 176

Demagnetizer Fits Variety of Shapes and Sizes

An improved design of coil is highly effective in demagnetizing materials and stabilizing magnetic flux. Any unshielded magnetically soft material, including forms of iron and steel, can be demagnetized by this instrument. The device can be used to eliminate undesirable magnetic flux from tools, drills, punches, small arms, and machined parts.

The demagnetizer is also useful in equalizing and stabilizing flux in permanent-magnets for electrical instruments and controls. In general, permanent magnets are magnetized to a flux density higher than that required in the finished product. The demagnetizer reduces the flux density, stabilizing it at the desired value.

The instrument is shipped complete and ready for use. It consists of an air-core coil built in a frame which can be mounted on any table or bench. The coil is rated at 115 v, 60 cycles, and is equipped with switch, pilot lamp, and a flexible lead fitted with a standard plug. It has a rectangular opening $4\frac{1}{2}$ by $8\frac{1}{2}$ in. to accommodate stock up to 8 in. wide. The coil axis is horizontal and mass production demagnetizing may be accomplished by passing a non-



metallic conveyor belt through the instrument parallel to the coil axis. Pieces of considerable length can be demagnetized, or several small pieces can be demagnetized simultaneously, provided they are not in a metal container and are not in sufficient contact to cause shielding of any of the pieces. Grease, dirt, scale, or rust do not affect the process. The coil is designed for incorporation in production machinery making permanent magnets and for testing and laboratory applications.

Special Product Div., General Electric Co., Schenectady 5, N. Y.

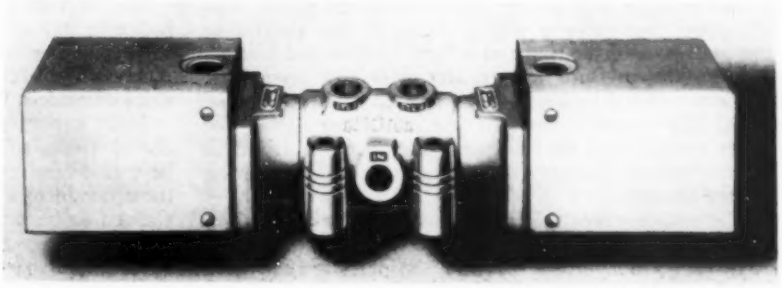
Circle No. 13 on Reader Service Card

Hydraulic Balance Gives Smooth Valve Operation

A double-solenoid, 4-way hydraulic valve is used as a semi-automatic electric control for a hydraulic circuit. The solenoids at each end of the valve body are continuous duty, push type. Energizing the solenoid on the right moves the valve piston to the left, and vice versa.

Principal feature in the design is the hydraulically balanced piston with integral spool and stem. The entire piston surface is hardened, ground and lapped, with special grooving to minimize binding at high pressure. The valves are offered double solenoid operated, either standard or spring-centered action; single solenoid operated with spring return; and solenoid pilot operated.

For pressures up to 1,500 psi, five sizes are available: $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1 in.,



ELECTRICALLY OPERATED 4-way hydraulic valves are designed to handle high pressures with low current requirements. The spool is moved by push-type solenoids at each end. Operating surfaces are hardened, ground and lapped.

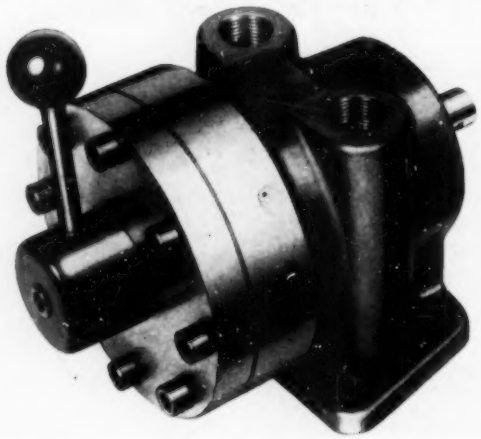
for standard 110, 220, and 440 v, 50 or 60 cycles. Non-standard current specifications furnished upon request.

The hydraulic balance feature reduces binding and increases the speed and reliability of operation. The mechanical solenoid force does not buck full line pressure to actuate the valve. Smooth spool surfaces are an added feature.

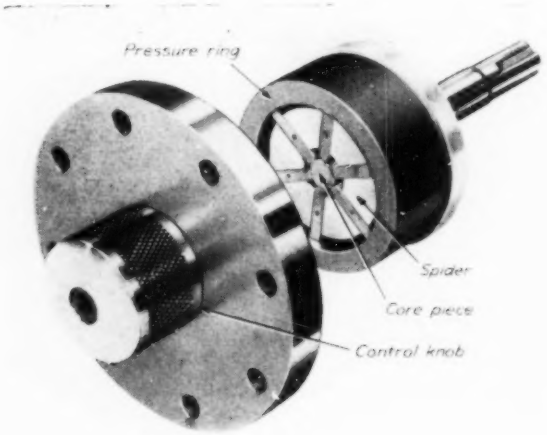
Rivett Lathe & Grinder, Inc., Brighton 35, Boston, Mass.

Circle No. 14 on Reader Service Card

CONTINUED ON PAGE 176



CAPACITIES 0 to 10 gpm in either direction are available in foot mounted, flange mounted, and stripped models. Handle controls discharge direction and displacement.



WIPING ACTION of the vanes over the inner bore is minimized by leaving the pressure ring free to rotate. This also reduces friction and heating.

Vane Pump Gives Variable Delivery in Either Direction

This pump provides adjustable displacement without heat-generating relief valves. It is a standard unit, production manufactured. The pump is also reversible. This feature can be used on closed circuit applications. The pump is independent of direction of rotation and can be driven from a power source which rotates only one way. It can be coupled to such a source and the direction of discharge adjusted to suit the hydraulic requirements of the installation. The piping of the circuit can also be arranged in the easiest way without worrying about intake and discharge sides of the pump. After the piping is complete, the pump is adjusted to discharge in the desired direction. A total of four pump connections are provided; two each for the intake and discharge. With this arrangement, sixteen different connection combinations are possible.

The pressure ring is free to rotate with the pump. This eliminates high velocity wiping action of the vanes over the inner bore of the ring and reduces friction and heating. Because the pressure ring rotates with the pump, the vanes are moved back and forth in their slots by a radial force. The tangential force component is very slight. The vanes are mounted radially, since the pump is driven in either direction. The spider design provides a long bearing for the vanes.

The vanes are held firmly in the spider and make positive contact between the pressure ring and the core piece, in any eccentric position of the spider in the pressure ring. Each vane is a section of a cylinder of diameter equal to vane length. The diameter of the core plus twice this cylinder diameter equals the inner diameter of the pressure ring. This gives the pump characteristics similar to a piston pump and allows low-speed operation.

The displacement is governed by the amount of eccentricity of the pump spider relative to the pressure ring. The direction of discharge depends on whether this eccentricity is to the left or right of center. The amount and direction of this displacement is controlled by an eccentric rocker shaft mounted in the cover plate. The outer end of this rocker shaft is adapted to receive any number of controls, including a simple knurled knob, a manually operated lever, and more complicated manual- or power-operated mechanisms.

Construction has been kept simple and rugged. The hydraulic passages in the body are short, direct and ample to keep the velocity of the oil below accepted limits. The pump is available in foot mounted, flange mounted, and stripped models. Capacities 0 to 10 gpm in either direction.

More expensive piston pumps have the performance characteristics of this unit. However, the manufacturers have used vane construction in the new model to incorporate these advantages into a low-priced pump. The cost is claimed to be only slightly above that of a conventional vane pump.

Hydropower Inc., Milwaukee, Wis.

Circle No. 15 on Reader Service Card

SEALED RELAY measures $1\frac{7}{16}$ by $1\frac{3}{8}$ by $1\frac{1}{16}$ inches. Mounts on 3 studs and has 3 solder-lug terminals. Contact combinations up to 4 pole DT. Advance Electric and Relay Co., 2435 N. Naomi St., Burbank, Calif.

Circle No. 16 on Reader Service Card

ROTARY ACTUATOR weighs less than 1 lb and develops 110 in-lbs maximum torque. Rotates 90 deg in less than 1 sec at rated 60 in-lb torque. Lear Inc., 110 Ionia Ave. NW, Grand Rapids 2, Mich.

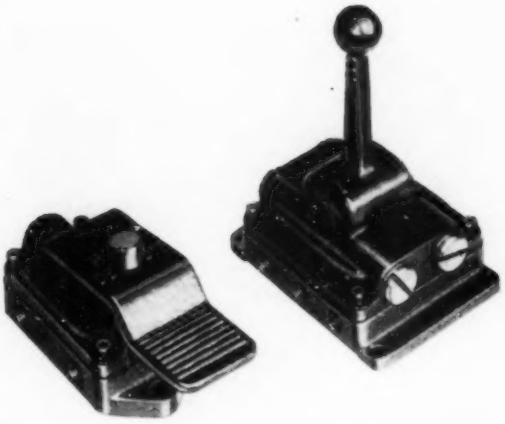
Circle No. 17 on Reader Service Card

PHOTOELECTRIC COUNTER operates at 10 ft range, 600 counts per min, from a standard wall outlet. No extra wiring is necessary. Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.

Circle No. 18 on Reader Service Card

CONTINUED ON PAGE 178

Interchangeable Parts Multiply Valve Applications

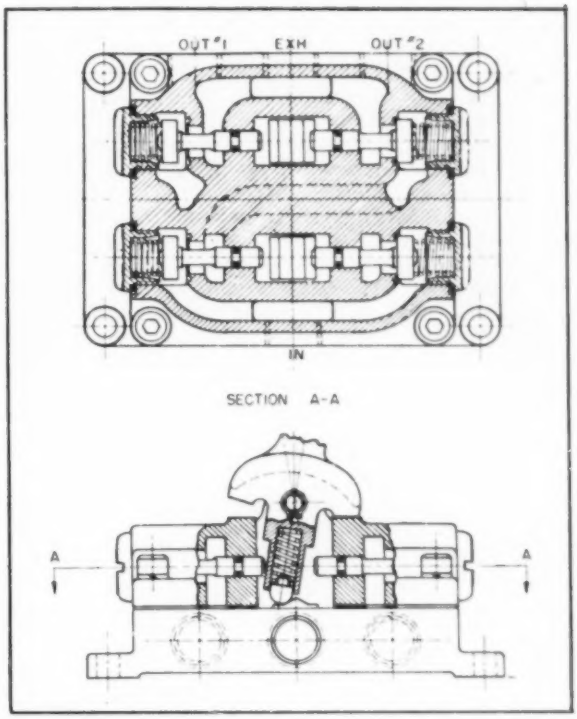


Chief feature of this valve is flexibility due to interchangeability of parts. It can be supplied with a vertical handle, a vertical handle with spring return, horizontal handle, horizontal handle with spring return, double-treadle foot lever, or foot lever with spring return.

A separate base permits manifold mounting. Bases are available for bottom or side ports. A level seat is standard, non-level optional. A two or three position locking arrangement, or non-locking, can be supplied.

The valve is available in 3-way or 4-way models, with $\frac{1}{4}$ and $\frac{3}{8}$ in. pipe sizes. Maintenance is simplified by design providing quick accessibility to all moving parts.

Ross Operating Valve Co., 120 E. Golden Gate Ave., Detroit 3, Mich.



INTERCHANGEABLE PARTS make this valve economical to manufacture and easy to apply. Vertical or horizontal handles, plain or spring loaded can be supplied in addition to single and double action foot valves.

Circle No. 19 on Reader Service Card

Plastic Insulation Does Not Support Combustion

A plastic electrical insulation which will not support combustion is being offered to the wire and cable and electrical industries. Flammability has been a characteristic disadvantage of plastics with good electrical properties. Tests with this material, however, have shown that it will not burn after the flame has been removed. Neither will it drip when molten, a further advantage, since hot plastic drippings can start fires.

Its electrical properties are comparable to, although not equivalent to, those of polythene, one of the best insulating materials known, particularly in high-frequency applications.

Power factor, over a wide range of frequencies, is 0.002, as compared with 0.0002 for polythene. Its dielectric constant of 2.7 compares with that of less than 2.5 for polythene. The new plastic insulation is non-tracking and retains its electrical properties after immersion in water for long periods at elevated temperatures. Its low-temperature properties may be classified as excellent and its mechanical properties as good.

Tests point to its use where flammability is a factor, as insulation for high-voltage hook-ups, signal-controls, television lead-ins, radio feed-backs, flame-retardant line wires, neon-signs, multi-conductor controls, and high-voltage street-light cables.

It can be extruded on to wire at high speed; it can also be injection molded. Molded electrical parts and extruded electrical tape are being developed for uses where flammability is a consideration.

This material is the result of extensive research on the flame resistance and combustibility of insulating plastics. It is the first material of suitable electric properties with a heat of combustion low enough to ensure that a flame applied to the insulation will not be self-sufficient. If the temperature is raised to the burning point by a short circuit or other outside conditions, the insulation will not liquify to the point of running into the other machinery.

Polychemicals Dept., E. I. duPont de Nemours and Co., Wilmington 98, Del.

Circle No. 20 on Reader Service Card

CONTINUED ON PAGE 180

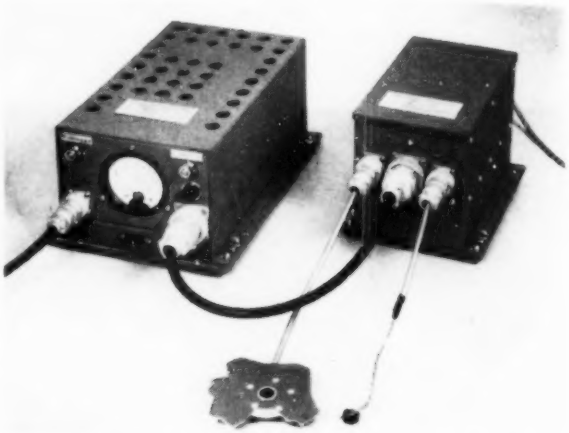
Pressure Cells Mount Without Flexible Tubing

Phase and amplitude errors from flexibile-tube connection of pressure cells used in dynamic measurement are eliminated in these flush-mounted cells by elimination of the tubing connections themselves. Cells mount directly in the surfaces which contain the measured pressures. Several styles are offered to fit various applications—including wedge-shaped types small enough to be used within $\frac{1}{2}$ in. of an airfoil trailing edge.

Having a natural frequency of approximately 2,400 cps, the cells exhibit a uniform frequency response between 0 and 250 cps. Units are listed with these sensitivities: 0 to ± 2.5 psi, 0 to ± 5 psi, and 0 to ± 10 psi. Phase accuracy throughout is better than ± 0.2 deg. Accelerations encountered on vibrating or oscillating surfaces are negligible in effect. With these characteristics, cell outputs can be combined electrically for measurements such as lift or hinge—and pitching-moments of ailerons. With this technique, complicated calculations are avoided.

Related equipment to provide for driving standard oscillograph elements from cell outputs includes carrier-frequency bandpass amplifier, oscillator, and power supply. The two-channel amplifier has dimensions $4\frac{1}{2}$ by $5\frac{1}{4}$ by $7\frac{1}{4}$ in.; weight, $5\frac{1}{2}$ lb. The oscillator power supply is $6\frac{1}{4}$ by $4\frac{3}{4}$ by $11\frac{1}{4}$ in.; weight, $10\frac{3}{4}$ lb. The $\frac{1}{2}$-in. cells weigh less than $\frac{1}{4}$ oz.

This equipment is applicable to the measurement of instantaneous aerodynamic forces of the types encountered in flutter-, transient-, and gust-studies in wind tunnels, or



CELL MOUNTS DIRECTLY in the surface where the pressure is to be measured. Amplifier controls standard oscillograph.

—because of the small size and light weight of the associated units—in flight.

Fluid pressure acts only on the surface of the cell. Here it is changed into a signal which is lead out to the instruments. The signal is read remotely instead of the pressure.

Sierra Electronic Corp., 1122 County Rd., San Carlos, Calif.

Circle No. 21 on Reader Service Card

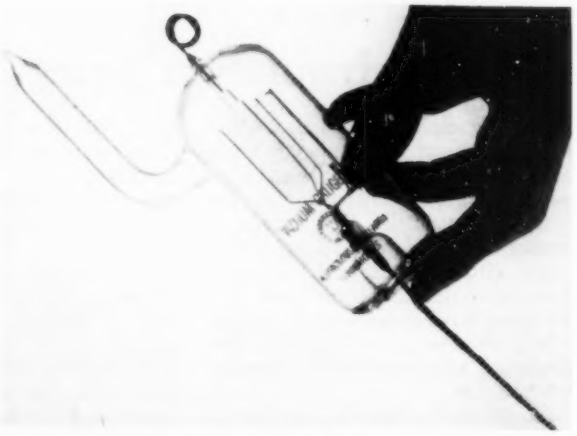
Ionization Gage Measures Very Low Pressures

An ionization vacuum gage measures pressures as low as 5×10^{-10} mm. Hg. Resembling a triode vacuum tube, the new gage has three elements—filament, grid, and ion collector. They are inverted from the conventional arrangement, however. The filament—of which there are two, one a spare—is outside the cylindrical grid. The ion collector, consisting of a fine wire, is suspended within the grid.

The volume thus enclosed by the grid is comparable to that between the grid and plate of the ordinary ionization gage. The positive potential on the grid forms a barrier to the ions formed inside the grid-enclosed volume. As a result, they are eventually collected at the center wire. The ion collection efficiency is thus comparable to that of the conventional ionization gage. Since the number of ionizing collisions for a given electron current is considered to be proportional to the gas density, the current on the ion collector is a measure of the pressure.

The simple construction used reduces the metallic surface in the gage. This makes it easy to outgas the elements by electron bombardment at temperatures above 1000 C, with power less than 100 watts. The hard glass enclosure is 2 in. in diameter by 5 in. high. The gage can be operated on standard power supplies.

The new instrument was developed to furnish a sensi-

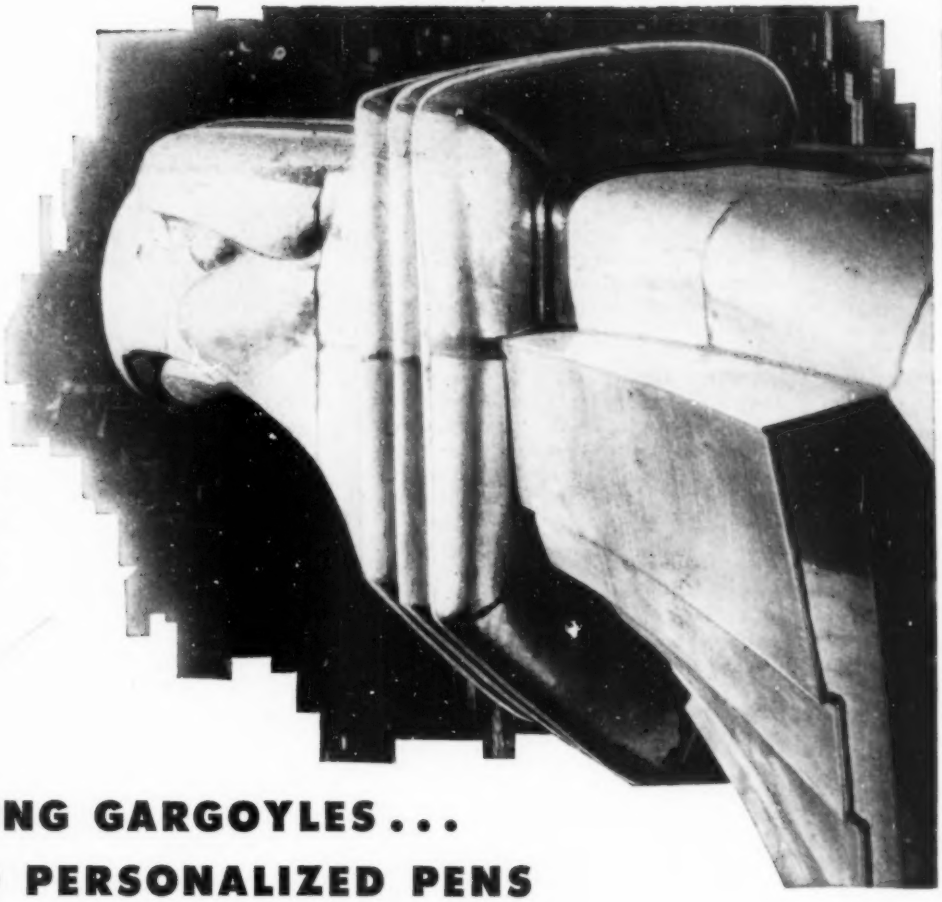


tive pressure gage to be used with industrial equipment. The resemblance to a standard tube simplifies production; the electronic measuring system is efficient at lower pressure levels than mechanical gages.

Electronic Tube Sales, Westinghouse Lamp Div., Bloomfield, N. J.

Circle No. 22 on Reader Service Card

CONTINUED ON PAGE 182

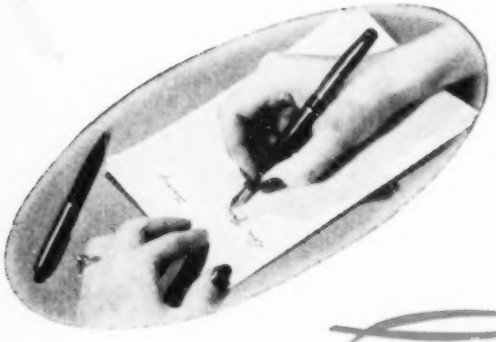


Although aptly named "The Thrifty Metal of 10,000 Uses," ENDURO probably has proved its efficiency and economy in ten times that many uses. Every day it adds to the figure.

FOR GLARING GARGOYLES . . . AND PERSONALIZED PENS

● High up on the Chrysler Building in New York City, the gargoyles and other trim of Republic ENDURO Stainless Steel are just as good as when installed some 20 years ago.

That's just what happens when ENDURO is used for building applications. It lasts indefinitely—requires little maintenance other than an occasional simple cleaning.



ENDURO is writing history, too, in fountain pens. It defies corrosion and wear—permits one manufacturer to make a full line of personalized points to suit each customer's need. In the cap and other parts of both pens and pencils, it adds that extra touch that says, "QUALITY."

What makes ENDURO so valuable throughout all industry? Why, its versatility. Resistance to rust, corrosion and heat—unusual strength and toughness—add up to long life and low maintenance cost. Sanitation, freedom from contamination and easy cleaning protect product quality—cut processing costs. Beautiful lustre changes eye-appeal into "buy-appeal."

You never know where ENDURO will be used next—in paper mills and paint factories—in movie cameras and milk tanks—yes, even in caskets. The list is endless.

Now, how about *your* product and plant equipment? There must be some place where ENDURO will pay its way. Why not let Republic engineers and metallurgists tell you where? Write us.

Distributors' stocks and competent fabricators are located in principal cities. Your local Republic representative is prepared to answer your questions.

Enduro® STAINLESS STEEL

REPUBLIC STEEL

RUST-RESISTANT • CORROSION-RESISTANT • HEAT-RESISTANT • ATTRACTIVE • SANITARY • EASY TO CLEAN
EASY TO FABRICATE • STRONG • LONG-LASTING • LOW IN END COST • What more can be desired in a material?

REPUBLIC STEEL CORPORATION • *Alloy Steel Division, Massillon, Ohio* • **GENERAL OFFICES, CLEVELAND 1, OHIO**

Export Department: Chrysler Building, New York 17, N. Y.

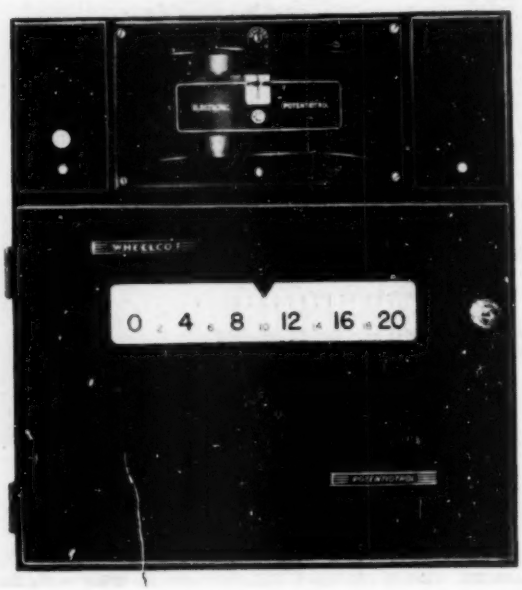
Electronic Instrument Controls Equipment

Temperature, speed, flow, pressure, static strain and a-c or d-c voltage or current can be accurately controlled by a recently developed instrument. Any elements producing electric potentials, such as thermocouples, radiation detectors or resistance bulbs, can be used for measuring the variable.

An internal battery furnishes a voltage which is applied across a 9½ in. slide wire resistance. The rider on this slide wire is attached to the pointer on the control scale of the instrument. Both are moved by the control knob below the scale. Setting a value on the scale applies a proportional voltage to a potentiometer measuring circuit. If this voltage is exactly equal to the potential from the control thermocouple or resistance bulb, the circuit is in balance. Any difference between the two, however, gives unbalance. The resultant error current tips the null indicator at the top of the instrument. This also moves a metal vane placed between two coils in the power relay control circuit, changing the frequency of the circuit and energizing the relay.

The relay controls the fuel valve, electric heater, etc., which corrects the variable. When the correction has been made, the relay returns to its normal position. A variety of two position and proportioning switches for 105-115 or 210-250 v, 50 or 60 cycles are available.

Wheelco Instruments Co., Chicago 7, Ill.



Circle No. 23 on Reader Service Card

Flame Resistant Hydraulic Fluid is Non-Toxic

This hydraulic fluid is non-toxic, flame resistant, and has good lubricating qualities. Chemically, it is an ester base compound, with no halogenated hydrocarbons, salts or water.

Special hose, gaskets and packing materials are necessary. A number of suitable elastic materials are available from the principle manufacturers. Gasket materials complying with specifications AN-G-171 and AAF-40231 are suitable. The fluid will soften most finishes that have not been baked. Several manufacturers furnish paints that are not effected, however.

No special protective precautions are needed in handling. The fluid is not an irritant to skin or eyes.

Low temperature pour point is —70 F; flash temperature is 435 F. The viscosity varies from 2.65 to 11.05 centipoises between 210 and 100 F. The fluid is slightly heavier than water and has a sweet odor.

Monsanto Chemical Co., Organic Chemicals Div., 1700 S. 2nd St., St. Louis 4, Mo.

PHYSICAL AND CHEMICAL PROPERTIES

Appearance	Clear, blue, oily liquid
Acidity	0.01
Moisture	0.25 Max
Odor	Slight, sweet
Refractive Index at 25 C	1.507 to 1.510
Specific Gravity	1.088 to 1.095
Specific Heat	0.42 BTU/lb/F
Thermal Conductivity	0.047 BTU/hr/ft²/F
Flash Point	435 F
Fire Point	460 F
Viscosity (centipoises) at 100 F	11.05
at 210 F	2.65
Viscosity Index	76
Pour Point	—70 F

Circle No. 24 on Reader Service Card

SANITARY MOTOR FINISH is baked white enamel. Capacities range from 3 to 7½ hp. U. S. Electrical Motors, 200 E. Slauson Ave., Los Angeles 54, Calif.

Circle No. 25 on Reader Service Card

STARTING RELAY for fractional hp, single phase motors mounts in any position. Saves space over centrifugal switches. R-B-M Div., Essex Wire Corp., Logansport, Ind.

Circle No. 26 on Reader Service Card

WIRE-WOUND RESISTORS, with 3 terminals at one end, meet JAN styles RB40B, -41B, and -42B. Wire leads also furnished. Shallcross Mfg. Co., Collingdale, Pa.

Circle No. 27 on Reader Service Card

CONTINUED ON PAGE 184

Flanged·and·Dished

HEADS

for Every Need

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Duplex Timer Controls Two Circuits Simultaneously

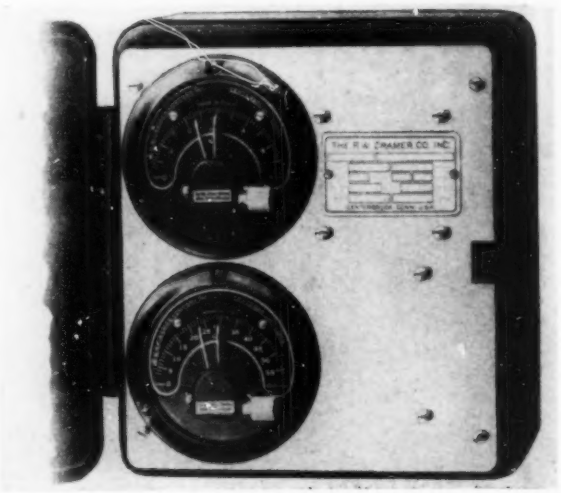
A combination of two timers built as one unit will open and close one or two load or control circuits. Operation can be continuous, or the timer can be set to perform one complete cycle and then stop.

Typical uses include the control of idle and running time of a machine; alternating the operation of two motors in a dual pumping installation; controlling the period feeding of chemicals to boilers; uniform reverse of gas flow in open hearth furnaces, and other industrial applications which require repeat-cycle operations.

Two styles are available. One for intermittent duty has a clutch built into the motor and operated by a magnetic effect on the rotor. The second type, suitable for continuous duty, has a clutch consisting of two gear members actuated by a small electro magnet.

Eleven different dials, ranging from 15 seconds with $\frac{1}{4}$ sec scale divisions to 5 hours with 15 min scale divisions are made. Unless otherwise specified, the timer resets to zero on power failure, to repeat the whole cycle.

R. W. Cramer Co., Centerbrook, Conn.



Circle No. 28 on Reader Service Card

Compact Reduction Clutch Shifts Under Full Load

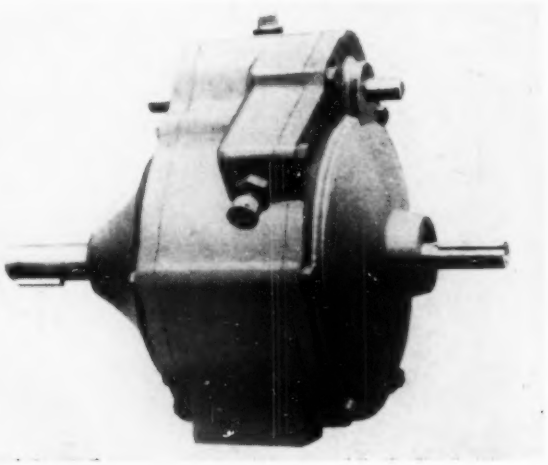
This reduction clutch operates without counter shafts or special reversing arrangements. The minimum reduction ratio is 4 to 1. Three positions, forward, reverse, and neutral are provided to transmit 2 to 12 hp continuously.

The entire unit is $9\frac{3}{8}$ in. long, $9\frac{3}{4}$ in. wide and $10\frac{3}{16}$ in. high. The axes of the input and output shafts are coincident. The clutch can be shifted or reversed under full load, without difficulty.

Quiet operation in reverse and forward speeds is claimed. The cast iron housing has been designed rigid enough to withstand service deflections and vibrations. The enclosure is dust-, dirt- and grit-proof, and oil-tight to hold the bath for the self-lubricating gears. Roller bearings support the shafts; pinions are hardened to 55 Rockwell.

Belt, chain or direct drives may be used. The clutch housings can be furnished for various mounting needs. Possible applications are materials handling vehicles and conveyors.

Snow-Nabstedt Corp., 239 Welton St., Hamden, Conn.



Circle No. 29 on Reader Service Card

MIRRORS reflect 93 percent of visable light from a surface of vacuum condensed aluminum with hard, transparent coating. Can be wiped and dusted. Zenith Optical Lab., 123 W. 64th St., New York 23, N. Y.

Circle No. 30 on Reader Service Card

LOCK SCREW bites into metal with rachet teeth on the under side of its head. Holds tight without washers. Hex, pan, truss and flat heads are available. Russell, Burdsall & Ward Bolt and Nut Co., Port Chester, N. Y.

Circle No. 31 on Reader Service Card

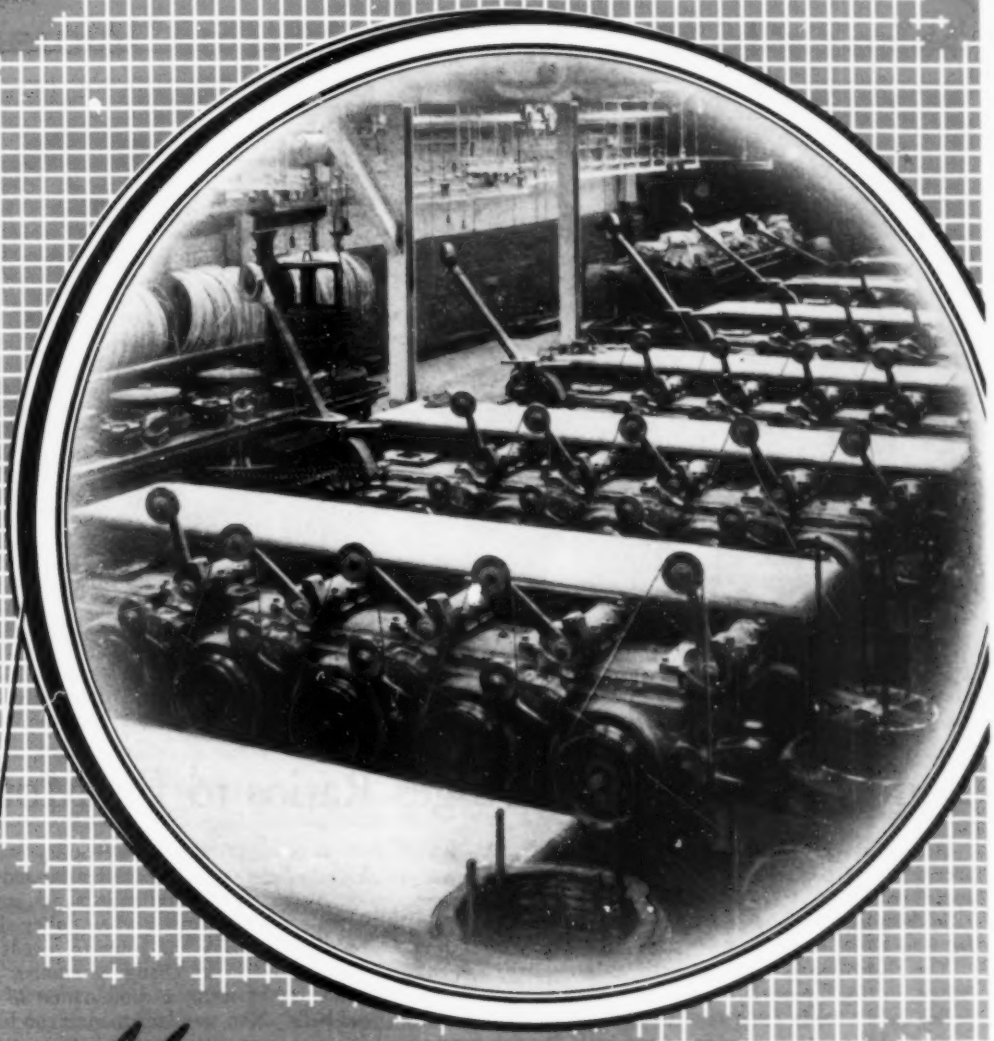
SHADED-POLE MOTORS are reversible in 6 pole, 1/30 to $\frac{1}{8}$ hp models. Extra-compact shaded-pole motors come 1/15, 1/20, 1/25 and 1/30 hp. Full load speed is 1,000 rpm, no-load 1,150. Fasco Industries, Rochester, N. Y.

Circle No. 32 on Reader Service Card

POROUS BRONZE BEARINGS, cored bar, solid bar, plate stock are oil-impregnated. Boston Gear Wks., 71 Hayward St., Quincy 71, Mass.

Circle No. 33 on Reader Service Card

CONTINUED ON PAGE 186



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AND DRAWS ITS OWN WIRE

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Industrial
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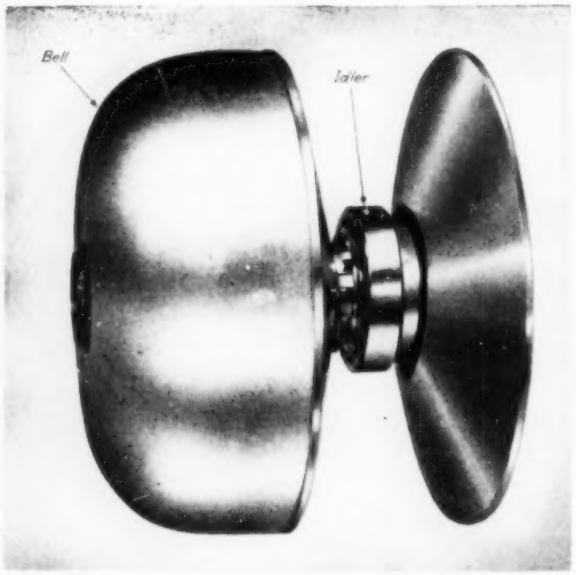
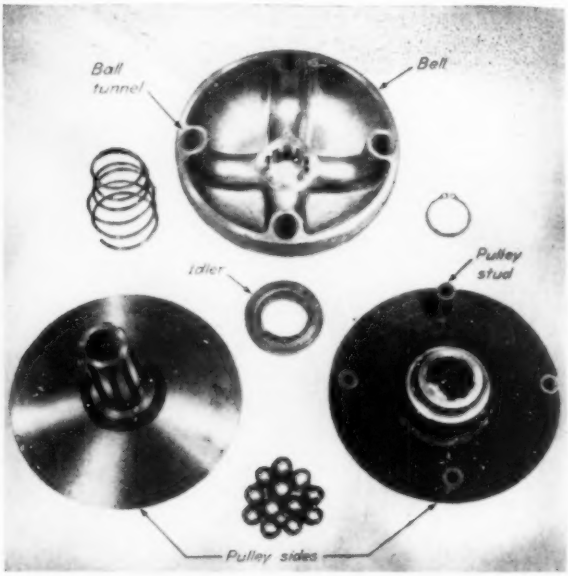
You can get wire cloth made exactly to your specifications—from Reynolds. That means more than woven to order. Because Reynolds, early in its 54 years of wire cloth making, began drawing its own wire—to control quality. That means the wire itself, as drawn by Reynolds, will be as *you* specify—*exactly right* as to metal, alloy, temper, flexibility, gauge and finish. And, of course, Reynolds weaves it to your specification—uniformly right as to weave and mesh. That makes it *your* wire cloth—made to meet all the needs of *your* product. You can depend on Reynolds engineers to carry out your specifications to the letter. Consult them. No cost or obligation.

Send for NEW Catalog

REYNOLDS WIRE CO., DIXON, ILLINOIS





VARIABLE PITCH PULLEY rides on motor shaft. Anti-friction idler carries belt when motor-pulley sides are spread, preventing wear. As speed increases, balls in ball tunnels are forced out centrifugally to push on pulley studs to increase pitch diameter. Clutch spring opposes this. Driven shaft pulley sides are spring loaded inward to retain belt tension.

Automatic Clutch Changes Ratios to Fit Motor Speed

An automatic variable-speed clutch, controlled by motor speed, has been offered. At low motor speeds, high-ratio speed reduction is obtained. As motor speed increases, ratio decreases. A standard 7½ in. diameter model is made for ½ to 1⅛ in. shafts. Other sizes are furnished on order.

The clutch works on centrifugal action. Balls are contained in four tunnels, spider-legged out from driving pulley hub. Studs from one side of pulley stop-up these channels. As motor speed increases, balls force themselves out in tunnels, pushing on pulley studs. This increases driving pulley pitch diameter by moving the adjustable side down the shaft on splines. A spring resists this and decreases pitch diameter when pulley slows down.

Various starting and running speeds can be obtained by changing belt size, changing number of balls in 2 or 4 tunnels or by using a combination of steel, aluminum or lead balls. Non standard models can be furnished.

Driv-Way Lite Co., P. O. Box 2850, Denver, Colo.

Circle No. 34 on Reader Service Card

Valve Holds High Vacuum

High vacuum valve requirements may be filled by a packless, high-vacuum, bellows valve, designed for applications which require a very low rate of leakage.

The valves are made with bronze bodies. A brass bellows completely seals the valves from atmospheric pressure, independent of valve position. The standard seat is Neoprene. Other seats, such as Teflon, are available.

Each valve is individually tested on a mass spectrometer type detector, capable of detecting leaks of less than 0.01 micron cubic ft per hour. Available at present are 1, 1½, 2 and 3 in. valves in globe screw and flange types. They are stock items, ready for immediate delivery.

High-vacuum equipment applications are expected in coating, dehydrating, evacuating electronic tubes, and laboratory experimenting. In general, the valves are suitable for any application which requires low pressure.

National Research Corp., 70 Memorial Dr., Cambridge, Mass.

Circle No. 35 on Reader Service Card

Diaphragm Carries Acids

Polytrifluorochloroethylene diaphragms combine resistance to chemical attack with the physical properties necessary in a valve diaphragm. The thermoplastic has been moulded into a tough, flexible sheet which withstands corrosives like chlorinated aliphatic and aromatic compounds, concentrated nitric, chromic, hydrofluoric and sulphuric acids, and most solvents which attack rubber and synthetic diaphragm materials.

The diaphragms are available only for the manufacturer's valves. These have been altered to use a backing sheet which cushions and protects the thermoplastic diaphragm.

Valve bodies may be cast of corrosion resistance alloys or lined with glass, lead, rubber or other impervious materials to suit operating conditions. Specifications cover pressures up to 100 psi.

Grinnel Co., Providence 1, R. I.

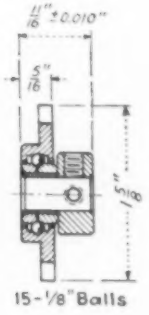
Circle No. 36 on Reader Service Card

CONTINUED ON PAGE 188

"Commercial" Ball-Bearing Data...#10 of a Series

WE WILL BE GLAD TO SEND YOU COPIES OF THE PREVIOUS ADVERTISEMENTS IN THIS SERIES.

How a special low-cost ball bearing eliminated assembly rejects

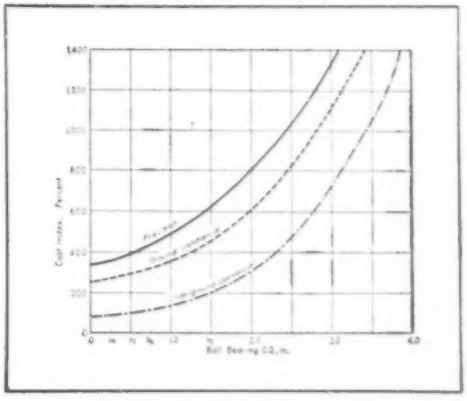


This Schatz "Commercial" Ball Bearing was specially designed to support the thread spool on a textile weaving machine operating at 2500 RPM under a 20-pound load. Previously, the spool had been held by a slotted washer, spot-welded to a standard bearing. Rejects were high, since the heat of the welding operation caused distortion of the balls and races.

Schatz engineers designed a new bearing with a split inner race and a flanged outer race to replace the washer. Result: the bearing could be used immediately without the costly spot-welding operation, and rejections due to heat distortion were completely eliminated.

Special "Commercial" Ball Bearings—like the one shown—are often less expensive than standard bearings, since costly assembly and machining time is eliminated. And many difficult anti-friction problems can be solved by various modifications in materials, inner and outer races or the ball arrangement. All "Commercials" can be furnished with single or double row of balls, felt or labyrinth seals, flanged or plain outside diameters, hardened or unhardened treads, set screws, Alemite fittings, extended inner race and hexagonal bores.

We will be glad to adapt or design a low-cost Special Ball Bearing to fit your specific job requirements.

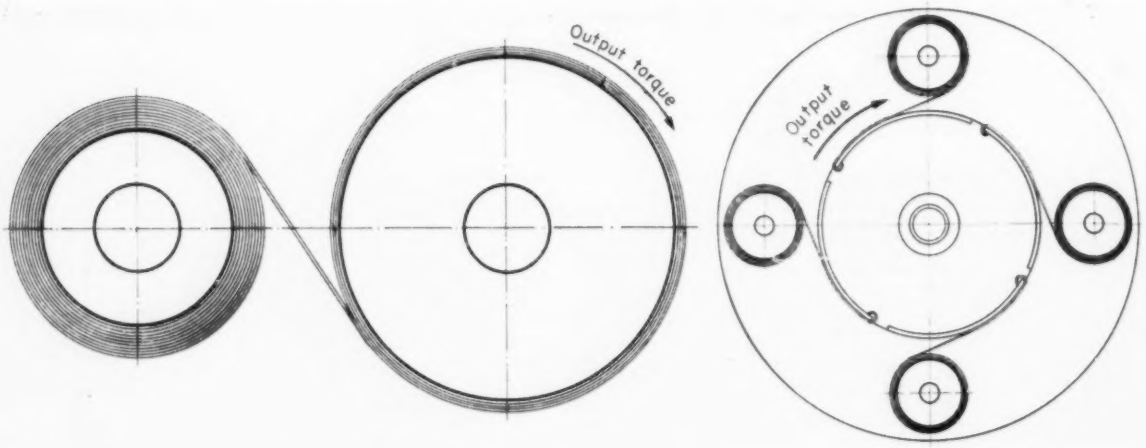


Relative costs of precision and "Commercial" Ball bearings. In very small sizes, the cost of precision bearings *increases* as the bore decreases, due to the difficulty in maintaining close tolerances. The cost of "Commercials" *decreases* in almost direct proportion to the size.

Write for "Construction and Characteristics of Low-Cost Ball Bearings." It tells how to select low-cost Schatz "Commercial" Ball Bearings for various load and speed conditions, gives classifications of standard types for radial, thrust or combination loads, and discusses the modifications that can be made for special design, assembly or operating conditions. Ask for Catalog No. 11, too. It gives complete data on the whole "Commercial" line.

SCHATZ
"Commercial"
BALL BEARINGS

The Schatz Manufacturing Company
6758 FAIRVIEW AVENUE, POUGHKEEPSIE, N. Y.



Spring Motor Gives Constant Torque Output

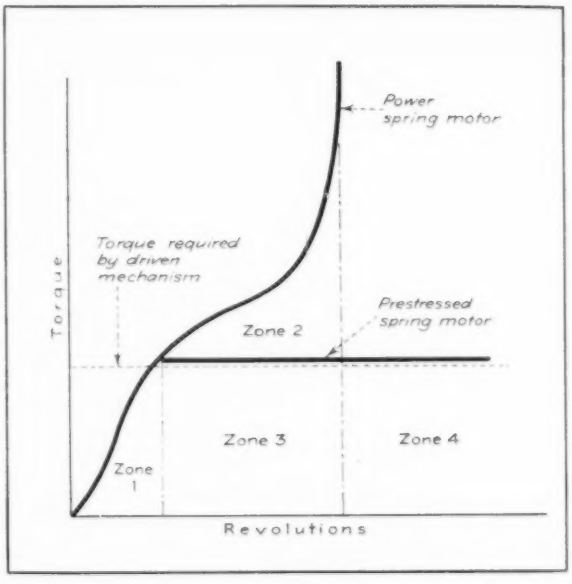
Constant torque output and long running time are advantages of a spring motor made of prestressed flat spring stock. The basic motor has three parts—the spring itself and two spindles. The band coils on both spindles in opposite rotational directions.

Constant, or even decreasing, force is exerted with increasing deflection. Usually, increased deflections of elastic members are accomplished by exerting greater force. In this spring, however, only a small increment of length is being deflected at any instant. The entire length of a conventional power or spiral spring is involved in generating torque.

Energy is stored by deflecting each increment in succession from its natural radius to a larger radius. Therefore, a spring mounted on a spindle of the same natural radius and forcibly wound onto a spindle of larger radius will run from the larger onto the smaller spindle when the external force is released. The greater the difference in the radiis of the two spindles, the greater the torque. Maximum output is achieved by back-bending the spring from one spindle to the other.

The conventional power spring cannot deliver its total available energy (Zone 1 + Zone 2 + Zone 3) because some minimum torque is required to operate the driven mechanism, and the spring must be initially wound to that torque. Thus the energy in Zone 1 is wasted. Further, the excessive torque delivered by a conventional spring in Zone 2, being beyond that which the driven mechanism requires, must be dissipated by some auxiliary mechanism, usually a governor.

In the new motor, the desired torque can be delivered over the entire range of extension, and the full amount of stored energy (Zone 3+Zone 4) utilized. Zone 4 in the graph is approximately equal to the area of Zone 1 plus Zone 2. Thus, long running times are achieved. In addition to greater efficiency, the motor develops no friction between coils, an energy loss which is a factor in the design of motors using conventional power springs.



Neg'ator Div., Hunter Spring Co., 1 Spring Ave., Lansdale, Pa.

Circle No. 37 on Reader Service Card

SINGLE PHASE CAPACITOR MOTORS are added to standard drip-proof line. Starting switch eliminates centrifugal switches. Sterling Electric Motors, Inc., Los Angeles 22, Calif.

Circle No. 38 on Reader Service Card

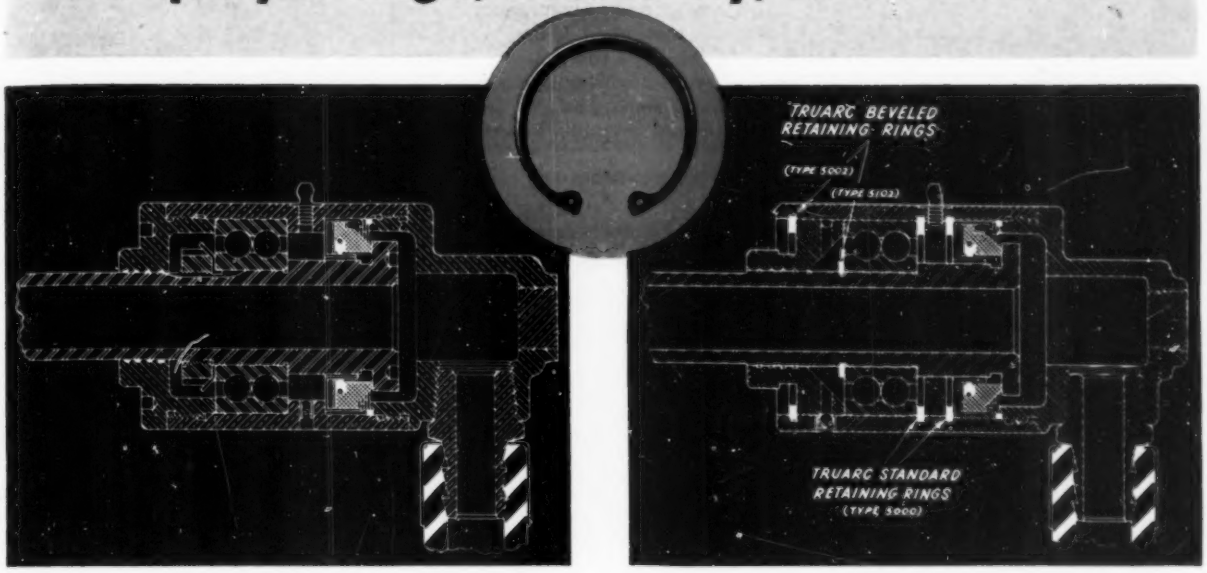
INCONEL "T" SECTIONS are available in standard size 1½ by 1½ by ¼ in., in lengths up to 15 ft, for high temperature designs. International Nickel Co., 67 Wall St., N. Y. 5, N. Y.

Circle No. 39 on Reader Service Card

PULSE GENERATOR produces 2 pulses controllable in width, amplitude and time relation to each other. Berkley Scientific Co., 6th and Nevin St., Richmond, Calif.

Circle No. 40 on Reader Service Card

4 Truarc Rings save $2.41 unit cost, Simplify Design, Assembly, Maintenance



Conventional Way. This design died on the drawing boards, because the Deublin Company, Northbrook, Ill., found the simplified design, using Truarc Rings, superior and more economical.

Truarc Way. Truarc Beveled Retaining Ring holds cap in place, takes up end play, locks entire assembly. Second Beveled Ring positions ball bearing on rotor. 2 standard Truarc Rings position bearing and removable seal, eliminate shoulders, permit manufacture of housing from strong, non-porous, easily machined brass tubing. Unit can be serviced in minutes simply by removing 2 Truarc Rings.

HOW $2.41 WAS SAVED

Materials saved	
decreased wall thickness of housing	$.79
eliminated bearing lock nut and washer	.18
	.97
Machine operations eliminated	
Bore, undercut, and tap cap end of housing	.39
Locate cap on arbor, and chase threads	.28
Drill spanner wrench holes	.10
Cut thread on rotor for lock nut	.09
Mill slot in thread for tang on lock washer	.18
Drill spanner wrench holes in rotor	.10
	1.14
Assembly operations eliminated	
Install lock washer, tighten lock nut, bend lug	.20
Assemble cap into housing	.10
	.30
TOTAL SAVINGS	$2.41

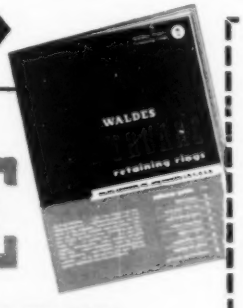
THE Deublin Union—a rotating joint for steam, air, or water—is simple, rugged, easy to service. 4 Waldes Truarc Rings hold entire unit together, permit simplified design, cut unit cost $2.41.

Improve and simplify your own product design with Truarc Rings, and you too will cut costs. Wherever you use machined shoulders, nuts, bolts, snap rings, cotter pins, there's a Waldes Truarc Ring that does a better job of holding parts together.

Truarc Rings are precision engineered. Quick and easy to assemble, disassemble. Always circular to give a never-failing grip. They can be used over and over again.

Find out what Truarc Rings can do for you. Send your blueprints to Waldes Truarc engineers for individual attention, without obligation.

SEND FOR NEW CATALOG



WALDES TRUARC

REG. U. S. PAT. OFF.

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WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS ARE PROTECTED BY THE FOLLOWING PATENT NUMBERS: U. S. PATENTS 2,382,948; 2,420,021; 2,411,761; 2,487,803; 2,487,802; 2,491,508 AND OTHER PATENTS PENDING

Waldes Kohinoor, Inc., 47-16 Austel Place PN102
Long Island City 1, N. Y.

Please send the new catalog on Waldes Truarc Retaining Rings.

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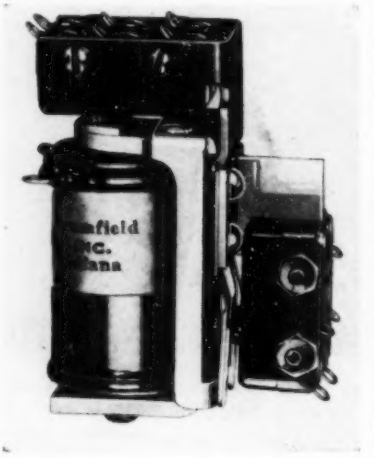
Compact Telephone Relay Takes Vibration

Miniature telephone-type relays, fitted with from one to four microswitches, are being manufactured. The assembly measures $1\frac{7}{16}$ by 1 15/16 by 11/16 in., has 4 contacts, and is rated at 24 v d-c. Maximum inrush for $\frac{1}{2}$ sec is 12 amps. The relay is claimed to withstand better than 50 G vibration.

The microswitches are bakelite enclosed to protect contacts and springs from environment conditions. Compact size and vibration resistance make this assembly particularly applicable to rocket, missile and aircraft installations. It may be used unhoused or hermetically sealed in a deep drawn steel can 1 by 11/16 by 2 5/32 in. high. The hermetically sealed assembly has either plug-in or solder terminals, with glass insulation. Actuating coils for either a-c or d-c are available.



Potter-Brumfield, Princeton, Ind.

Circle No. 41 on Reader Service Card

Light Torque Turns Sensitive Potentiometer

A low-torque potentiometer is now in commercial production. Primarily designed as an industrial or aircraft instrument component, the potentiometer may be used in any installation where a small mechanical force must be converted into a corresponding electrical voltage. It can be operated by the minute hand of a wrist watch or the pointer of an aneroid barometer; shaft torque can be as low as 0.003 in. ounces.

Designs are available to carry currents up to 0.1 amp. Outputs operate indicating, recording, or controlling

Here's how to anchor a cordset to an electrical appliance

to Increase Product Life

Slip a HEYCO Nylon Strain Relief Bushing on wire. *(Heycos eliminate cord wear at chassis entrance.)*

Snap HEYCO into chassis hole. *(The Heyco imparts a positive non-slip grip; does not injure wire.)*

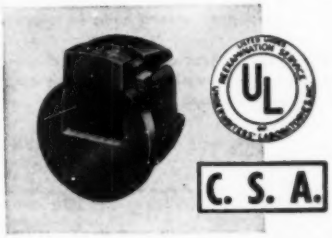
HERE'S WHAT A HEYCO WILL DO

1. Save time—reduce costs
2. Absorb cord pull, push and torque
3. Insulate wire at chassis
4. Prevent fraying
5. Eliminate tying knots
6. Improve appearance of product

HEYCOS ARE USED ON MANY PRODUCTS

You will find HEYCOS being used on an increasing number of nationally known appliances . . . toasters, heaters, clocks, roasters, mixers, record players, radios, television sets, toys, lamps, polishing machines, etc.

HEYCOS ARE MADE IN 11 SIZES
for clock wire to S-10/3 cable



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HEYCO

HEYMAN MANUFACTURING CO.
KENILWORTH 3, N. J.

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We've been telling You in print . . .

but there may be many questions on zinc die castings we have left unanswered. For that reason we will welcome the opportunity to talk with you—in person—at the National Metal Exposition in Chicago. We will have many zinc die castings —and pressed powder parts—on hand, as well as many of the finished products in which they are used.

Now - You can see for yourself . .

Visit with us at

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NATIONAL METAL EXPOSITION

International Amphitheatre

Chicago October 23-27

why ZINC DIE CASTINGS *are the most widely used . . .*

* A complete set of these advertisements will be sent to you upon request.

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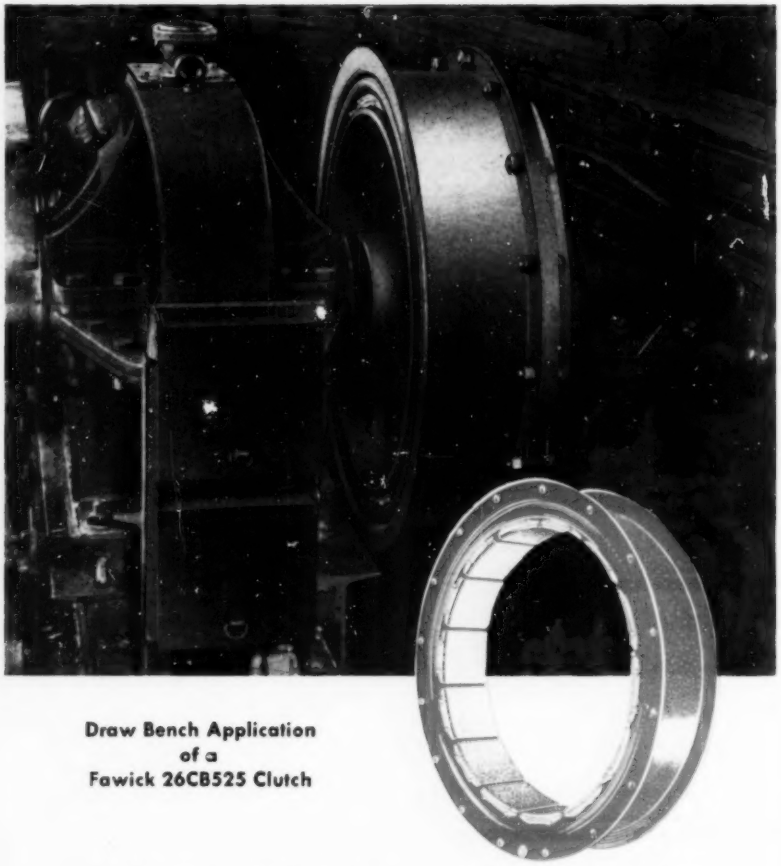
HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

GIVE YOUR MACHINES

CONTINUOUS PEAK PERFORMANCE

WITH

FAWICK CLUTCHES



Draw Bench Application
of a
Fawick 26CB525 Clutch

Fawick Airflex design and construction provide Fawick-equipped machines with every factor for high-efficiency clutch performance and unparalleled low maintenance.

Precision-built and engineered to each specific application, Fawick units eliminate the problem of "waste motion" mechanical linkages and other outmoded devices. Fawick provides:

1. **FULL POWER OPERATION** *through 360° radial friction contact at the maximum diameter, thus insuring greatest torque.*
2. **SHOCK-FREE PERFORMANCE** *because of operating torque being transmitted through the flexible rubber tube.*
3. **REDUCED MAINTENANCE** *through elimination of clutch lubrication and adjustment for wear.*

These and many other operating features make Fawick Airflex Clutch or Brake Units your logical specification to assure continuous peak performance on your machines.

For specific information on all advantages of Fawick Industrial Clutch and Brake Units, write to the Main Office, Cleveland, Ohio, for Bulletin 300.

All desirable clutch characteristics are built into Fawick Airflex units

FAWICK Airflex CO., INC.

9619 CLINTON ROAD CLEVELAND 11, OHIO

FAWICK CLUTCHES = + + + = PEAK EFFICIENCY

AXIAL CONTACT 360° RADIAL CONTACT SHOCK ABSORPTION CONTROLLED TORQUE

devices without amplification, giving savings in cost, size, and weight. In computing devices the reduced torque permits the use of smaller motors.

The potentiometer can conform to individual customer specifications. Resistance values between 50 and 200,000 ohms are provided for.

A shaft seal gives protection against dust; instruments are supplied with ball, sapphire, or bronze bearings. The circular resistance element is wound with non-corrosive alloy wire; severe service conditions may even demand platinum. Long life is provided by anti-fungicide treatment of insulating parts, and by plating or anodic treatment of metal parts subject to corrosion.

Accuracies as high as 0.05 percent are available. Satisfactory operation under vibration at frequencies up to 200 cycles per second have been demonstrated in use.

Approximately $1\frac{1}{2}$ in. long and $1\frac{1}{4}$ in. in diameter, the instrument weighs less than 1 oz, and can perform within the specified operating limits when subjected to accelerations of over 100 G's.

Electro-Mec Laboratory,
225 Broadway, New York 7, N. Y.

Circle No. 42 on Reader Service Card

Variable Transformers Are Explosion-Proof

These explosion-proof transformers provide a safe means of obtaining continuously-adjustable a-c voltage in hazardous areas where a small arc or spark could cause an explosion. A variable transformer is totally enclosed in a case which will withstand internal explosions. The case prevents the ignition of the gas or vapor surrounding the enclosure by internal spark, flash or explosion.

The transformers are Underwriters'

New Townsend Tufflok Nut Is Tougher Three Ways To Give You Tighter Grip, Greater Safety, With Economy

You get a tighter grip, greater safety and economy with the new Townsend Tufflok nut. It gives you more service at less cost. The exclusive Tufflok design*, plus the materials in the insert and nut body combine to give you the toughest lock nut yet produced for any use where nuts must stay put under a variety of adverse conditions.

Here are the New Exclusive Features of the Townsend Tufflok Nut:

1. *Tough hexagon insert*—won't turn in its seat, gives you positive grip on the bolt at all times. Specially treated insert resists moisture, oil and drying out. Special inserts where special applications are required.
2. *Tough, one piece cold forged nut* has exclusive petal design to assure positive insert staking.
3. Tough threads *cut in cold forged steel* are stronger, spin on easier, resist galling, speed up application and also afford more reuse.

The quality, efficiency, and safety with economy, you get in the new Townsend Tufflok nut is made possible by the skill and experience gained by The Townsend Company as the oldest manufacturer of small cold formed fasteners in the United States. This know-how combined with the background of The Nylok Corporation in producing millions of lock nuts gives you the advantage of a reliable source for your lock nut requirements.

The new Townsend Tufflok nut with exclusive hexagonal treated insert and special cold forged body is available in machine screw sizes No. 4 through 3/8", cadmium or zinc plated. This line will be increased in the near future.

For longer service with greater safety and economy specify Townsend Tufflok Nuts. Write today for samples and complete information.

THE TOUGHEST LOCK NUT EVER PRODUCED

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v, 15 amp output.

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Hannon Ave., Bristol, Con*

Circle No. 43 on Reader Service Card

Lead Anchor Holds Machine Screw

Machine screws anchoring condui
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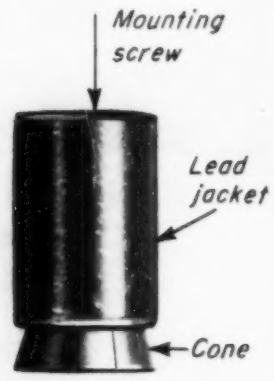
by a lead anchor. A hole is drilled
in the masonry. The anchor is then



driven into the hole, cone down. The
cone is an extension of a steel cor
with a threaded hole in the center
the lead is a cylindrical jacket.

With the anchor in the hole, a
setting tool pounds the lead jacket
down around the cone and into the
crevices in the hole sides. A mount
ing bolt screws into the hole in the
core.

Holub Industries Inc., Sycamore, Ill.

Circle No. 44 on Reader Service Card

Flange Housing Holds Tiny Ball Bearing

Miniature ball bearings are de
signed to facilitate mounting and as
sembly; punched sheet metal housings
can be substituted for precision ma
chined castings. The bearing illus
trated has a 3/32 in. bore, 5/16 in.
minor OD and 23/64 in. flange
diameter. The outer raceway and OD
are ground.

Other sizes range from 0.055 to
3/16 in. bore, from 3/16 to 5/16 in.

OD. Retainer and full-race designs are available. Dimensional tolerances range from ABEC1 (standard precision ground bearings) to ABEC7 (ultra precision). Standard material is high carbon chrome alloy steel; other metals are available as specials.

In small instruments and mechanisms, the capacity of the bearing can be designed to fit the actual load. Friction torque, surface speeds, space and weight requirements, centrifugal forces and moment of inertia are reduced from the values for over-capacity bearings.

New Hampshire Ball Bearings, Peterborough 1, N. H.

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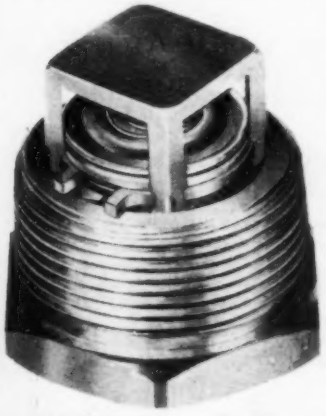
Check Valves Install In Standard Fittings

There are only three parts, plus a seat and a locking ring in this check valve. The assembled unit screws into any standard pipe fitting. One valve takes the place of swing checks, ball checks and clapper checks.

The valve member is lapped to the



seat. Since the valve continually rotates, re-lapping is required only in unusual cases. For this contingency, a locking ring is employed in order to simplify disassembly.

Durable Mfg. Co., 114 Liberty St., New York 6, N. Y.

Circle No. 46 on Reader Service Card

Coupling Jaws Hold Insert

Concave jaw surfaces hold synthetic rubber insert or spider in position. The tendency of the rubber to extrude or break is decreased. Metal jaws are manufactured to close tolerances; inserts are oil-resistant rubber. Avail-

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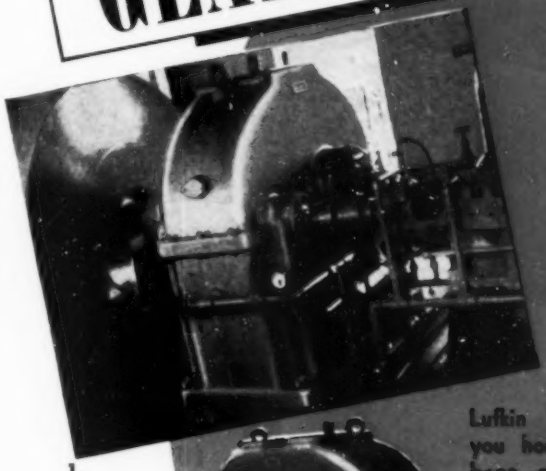
Lufkin



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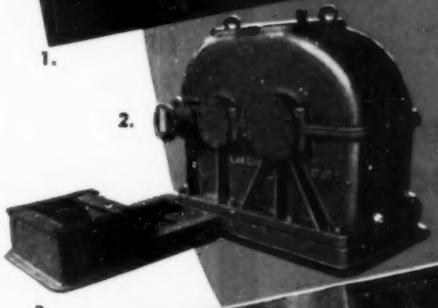

2.

3.

Lufkin Gear Speed Reduc... and Speed Increasers are ... pendable performers in ind... try's toughest services. A ... installations are shown here. ... Couch and Press Sections ... Newsprint Machines, Refiner... Chemical Plants and the ... Field number among other L... kin installations where stami... and ability are so important. ... Lufkin gear specialization can ... of particular value to you ... as you plan for the most in ... saving, outstanding equipm... operation.

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2. Large double reduction Gear R... ducer with motor base for Georg... paper mill.
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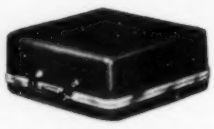
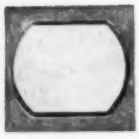
Excellent Dielectrically	Buffed—Polished	Bright or Somber Colors

• Tote Box



• Smith-Corona Typewriter Case



• Television Mask

• Home Freezer Breaker Strip

• Bowling Post for Brunswick-Balke-Collender Co., Inc.

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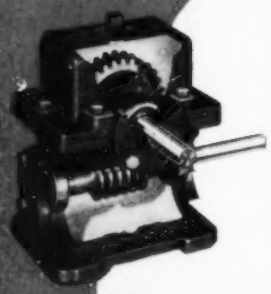
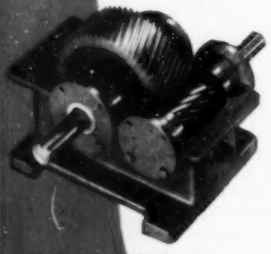
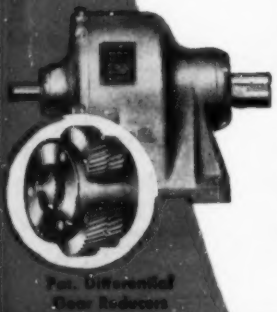


Worm Gear Reducers



Helical Gear Reducers



Pat. Differential Gear Reducers

Designing machines to embody standard components is naturally a cost-saving, time-saving factor . . . but of equal importance — a vital *selling* factor.

In selecting speed reducers, like other accessories with moving parts, this is particularly true. Design engineers can not afford to lose sight of the user who, from the very beginning, likes to know that he won't be faced with the delays of custom fabrication, should replacements become necessary.

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OUR READERS SAY

The Crank and Slot Drive

To the Editor:

In the article "Kinematics of the Crank and Slot Drive" by Mr. S. Rappaport, printed in the July issue of PRODUCT ENGINEERING, the mechanism is presented in a way which does not give it sufficient advantages over elliptical gearing—except the cost.

The crank is described as a driver and the "slot" is driven. In this case, maximum acceleration changes rapidly into maximum deceleration if m is high or when the ratio of maximum velocity over minimum velocity is sufficiently high. Rapid variation of acceleration means rapid variation of inertia forces. This condition causes higher stresses in the driven mechanism and, consequently, vibrations. In addition, near the moment of highest velocity, the driven member has a very small leverage, which increases the force acting on the crank pin.

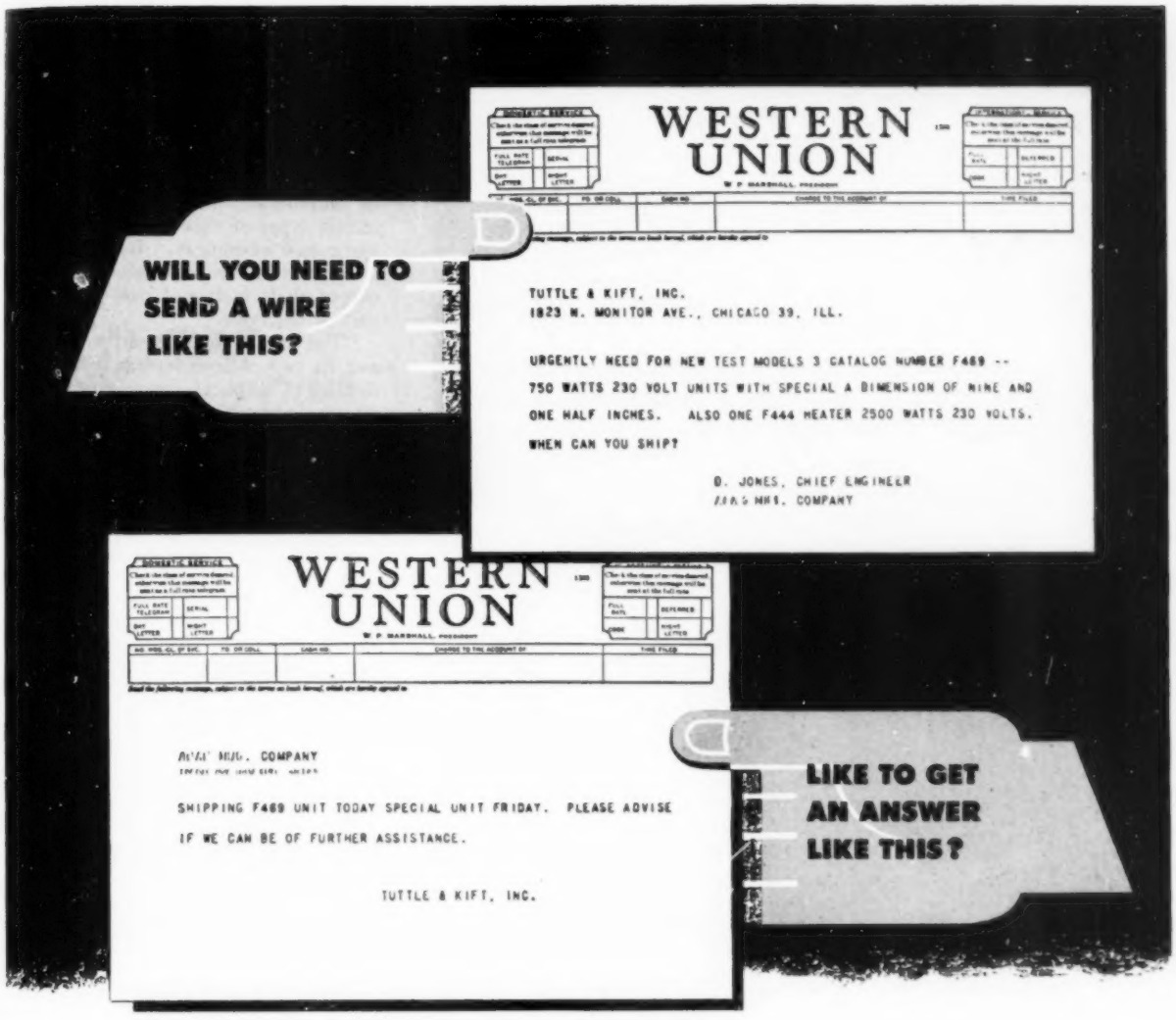
The proper solution for this drive is to reverse the driving and the driven members; that is: the slot should be the driver and the crank should be driven. In this case, the equation for displacement, velocity and acceleration becomes more complicated, but the variation of acceleration is more favorable and it can be used for a greater velocity ratio.

—C. N. NEKLUTIN
Ferguson Machine & Tool Company

Ed—Author Rappaport's rebuttal follows: "Mr. Neklutin's comment answers itself in his last sentence: '. . . elliptical gears, which have the same unpleasant characteristics as the arrangement of cranks described in the article.'

"The subtitle of my article is: 'A low-cost substitute for elliptical gearing'. It is also pointed out in the article how closely the equations of motion of the crank and slot drive resemble those of the elliptical drive.

"Interchanging of driver and driven member, as Mr. Neklutin suggests, would first convert the displacement equation—Eq. (1) in the article—into its inverse function, changing velocity and acceleration equations accordingly; and, as Mr. Neklutin rightly observes, their characteristics differ greatly from the elliptical drive. Hence this motion could not be con-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sidered an equivalent to the elliptic drive. As the curves show, crank and slot as well as ellipses have a short-time velocity peak, a feature which, pleasant or not, is sometimes necessary (whip-action of cross cut knife; or intermittent tobacco conveyor in certain types of cigarette machines, to name two examples). If the "slot" is the driver, the peak velocity of the output shaft is spread over a longer part of the cycle.

"The crank- and slot-drive can be put to two different uses: either to duplicate elliptical gearing (which was the purpose of the article) or, by interchanging input and output shaft, to achieve a modified motion."

Epicyclic Gear Problem

To the Editor:

We would like some information on how to select the proper gears to obtain a given ratio when using a simple epicyclic gear train.

The formula

$$F = 1 - \frac{C}{Y} \times \frac{X}{B}$$

gives the rotation of the follower or driven member per revolution of driver; and R (final ratio) equals *one* divided by F. It is simple enough to get the final ratio when the gear sizes are known, but the difficulty lies in the proper selection of gears to get a specified ratio.

We would appreciate any assistance you can give us.

—Walter L. VanDam
Atlas Press Company

Ed—As the equation above stands, there are two variables, x and y. This relation can be solved more readily if one of these variables is eliminated by substituting, for example, the equation x equals $(y + c) - b$. In this way the solution of y can be found more readily.

This problem can be solved graphically. Assuming these are fixed centers and the final ratio is known, it is possible to determine the pitch diameters of all four gears. Referring to the sketch, the procedure is as follows:

(1) Lay out the centers.

(2) Draw two angles which correspond to the angular velocities of the driver and driven members, ω_a and ω_b.

(3) Choose a diameter of gear c which is fixed. This locates r the instantaneous center.

(4) Draw line rs.

(5) The intersection of rs and the angular velocity line of the driven

TIP...

FOR THE DESIGNER

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No Line Oiler -
and 4,892,900
Strokes With

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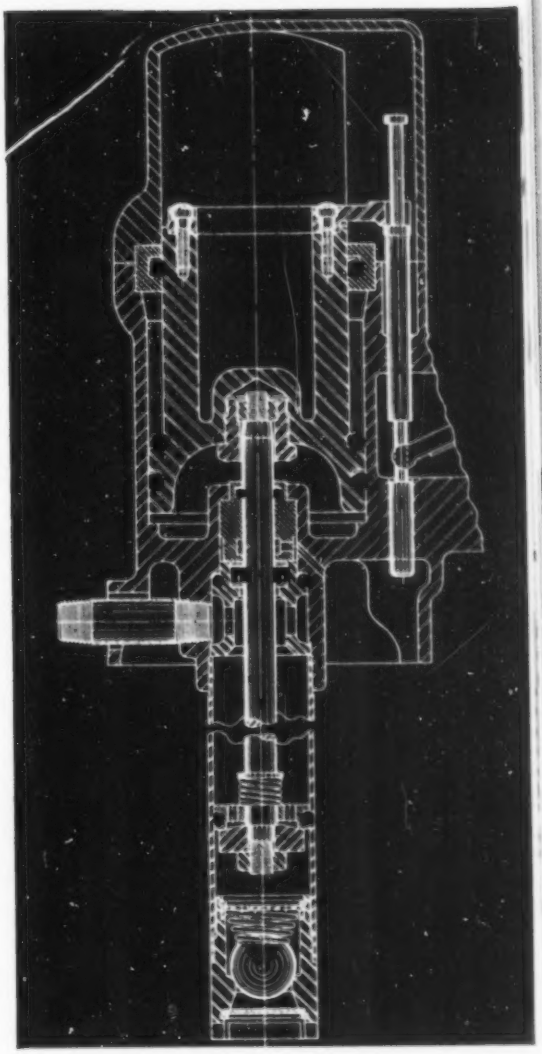

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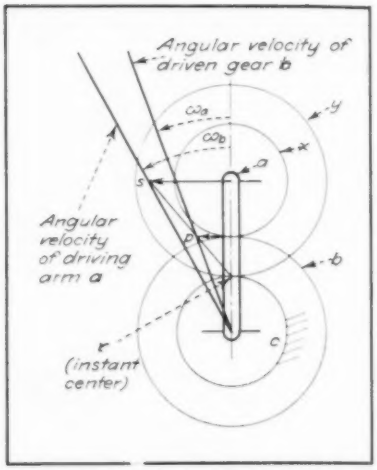

member determines point p.

(6) Projecting a horizontal line from p to the center line determines the pitch diameters of gears x and b.

(7) Instead of Step 3, the pitch diameters of gears x and b can be chosen and the line rs used to find the instant center.

Refrigerant Switchover

To the Editor:

I enjoyed reading the Highlights section in the June 1950 issue of PRODUCT ENGINEERING. The item concerning the advantages of adding difluoroethane to Freon 12 in compressor systems was of particular interest.

The first question that comes to my mind is whether or not this compounded refrigerant is toxic or has an objectionable odor.

The second question concerns the changes required, if any, such as compressor modifications and replacement of pressure controls.

—E. IMBODEN, JR.
Vallejo, California

Ed—This refrigerant was developed at the Carrier Corporation by Dr. W. A. Pennington and his associates in their Research Department. Dr. Pennington's answers to the above question follow:

"The new refrigerant that we have developed is an zaeotropic (constant boiling) mixture of unsymmetrical difluoroethane and Freon-12. It should not be regarded as Freon-12 plus an additive.

"We have named this non-flammable mixture Carrene-7. It boils at 32 F and contains 26.2 percent by weight of difluoroethane.

"To answer your two questions: (1) Carrene-7 is not toxic and has no ob-

jectionable odor; (2) the same tubing, controls and compressor used with Freon-12 can be used with Carrene-7. It will be necessary for the motor to have sufficient capacity to take care of the 18 percent increase in load.

"Difluoroethane itself is flammable; therefore, we discourage additions of this compound to Freon-12 in the field.

If the refrigerant Carrene-7 is used in a refrigeration system, it should be charged as such having been made to its exact composition by the manufacturer."

Electrically Conductive Coating

To the Editor:

Would be pleased to receive additional information on the resin cement as well as silicone-glass molding compound as announced in the Nonmetallic Materials section of the May issue under "Highlights".

We are also very much interested in getting information on a paint or carbon material which can be applied as an electrical heating element. We manufacture a baseboard electrical heating system and have been using a wire element which we attach to the board.

We now wish to use an element that can be applied directly to the aluminum board.

Any help you can give us will be greatly appreciated.

—G. A. MOORE
Moore Equipment Company

Ed—The resin cement is a product of Pronto Seal, Incorporated, 1133 Broadway, New York 10, New York; and the glass is made by the General Electric Company, Chemical Department, Pittsfield, Massachusetts. GE has designated this material by the number 12810.

The Pittsburgh Plate Glass Company, 2222 Grant Building, Pittsburgh, Pennsylvania makes a product called Nesa Glass which has an electrically conducting film on the surface. Possibly this surface material can be obtained and used in your application. Also, engineers at the Naval Ordnance Laboratory in Silver Spring, Maryland have been experimenting with materials that they call Markites, which are electrically conductive. A third possibility is the "Hot Paint" mentioned in the Nonmetallic Materials section on page 3 of this issue. The maker is the Electrofilm Corporation, 7116 Laurel Canyon Boulevard, North Hollywood, California.

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For instance: the accuracy of water meters depends on strength, long-life, and stability of the hard rubber parts—expected to last 10—even 20—years under water. Here fatigue resistance is vital, as the parts may go through 50,000,000 or more cycles in a lifetime.

With many different Ace Hard Rubber molding compounds, sheets, rods and tubes to choose from—also other Ace plastics such as Ace-Tex, Parian, Saran—you can select just the right combination of technical properties. And with our complete molding, extruding and fabricating facilities (among the world's largest) at your service, your job will be done the best way, the quickest.

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NEW BOOKS

Mechanics—A Textbook For Engineers

JAMES E. BOYD *and* PERCY W. OTT, *former and present Professor of Mechanics, respectively, The Ohio State University. Third Edition. 422 pages, 6 x 9 in. Published by the McGraw-Hill Book Co., 330 W. 42nd St., New York* 18, *N. Y.* $4.50.

Throughout this third edition of this textbook for engineers, as in former editions, in the presentation of subject matter a consistent emphasis is given to the application of the principles of mechanics to the analysis and solution of engineering problems, rather than on rigorous mathematical proofs and derivations of basic formulas.

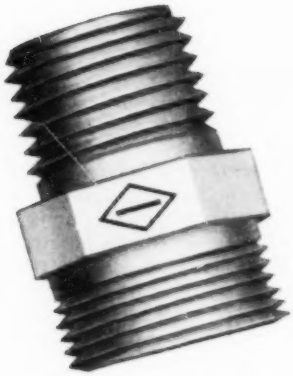
To enlarge the scope of the book and to improve the presentation, much of the material appearing in the earlier editions has been rewritten. The former chapter on Application of Forces has been extended by the addition of a full chapter on Machines and Friction. A new chapter on the Method of Work has been added in the new edition. The chapter on Graphical Methods has been enlarged by the inclusion of problems that are more advanced. A simple method of computing moments in space by determinants has been introduced in the discussion devoted to the treatment of forces in space.

In addition to retaining many of the former exercise problems, numerous new problems are scattered throughout the text. These latter problems are generally more difficult of solution than are the original ones. To further supplement the subject matter, many new illustrations have been added.

Proceedings, Sixth Annual Meeting, Metal Powder Association

92 pages, 9 x 6 in. Published by Metal Powder Association, 420 Lexington Ave., New York 17, *N. Y.* $2.50

A new type of stainless steel powder, application of iron powder in radio and television circuits and the market outlook for metal powders are among the subjects covered. Other papers, all presented by authorities in the field and included in the Proceedings, deal with cost accounting for



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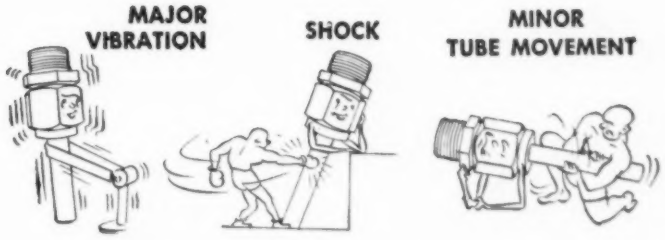

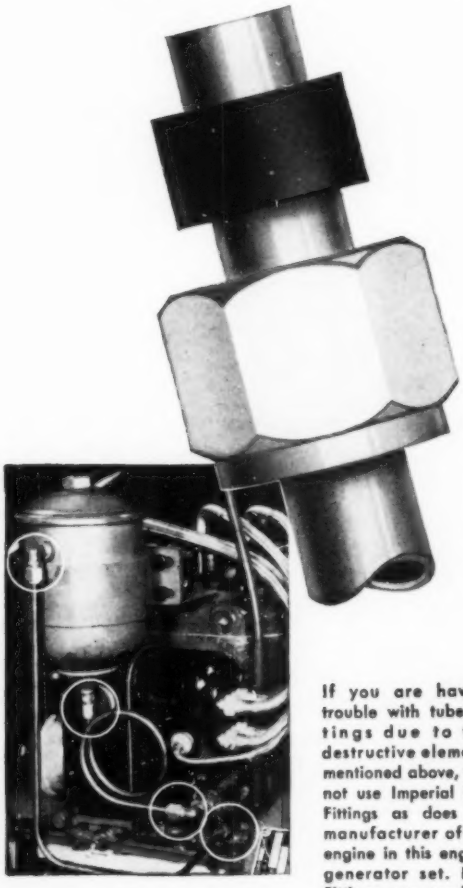

If you are having trouble with tube fittings due to the destructive elements mentioned above, why not use Imperial Flex Fittings as does the manufacturer of the engine in this engine-generator set. Flex Fittings are used as standard equipment on trucks, tractors, diesel engines, oil filter connections, heavy power equipment, machinery, etc.

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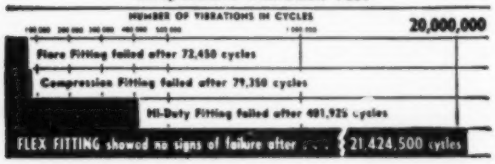
NUMBER OF VIBRATIONS IN CYCLES
20,000,000
Flare Fitting failed after 72,450 cycles
Compression Fitting failed after 79,350 cycles
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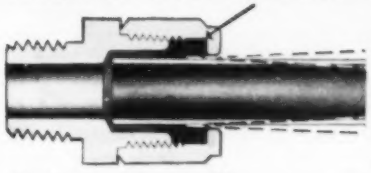

Easy to Install . . . All that is necessary is to slip nut and Flex sleeve over tubing. Then insert tubing into body as far as it will go and tighten nut to shoulder on body. No guesswork on how far nut should be screwed down. On sizes larger than ½" O.D. and where higher pressures are involved, end of tubing should be belled slightly.

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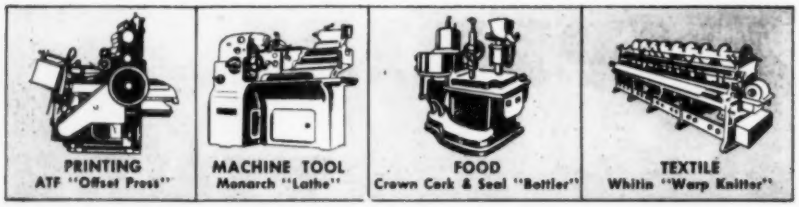

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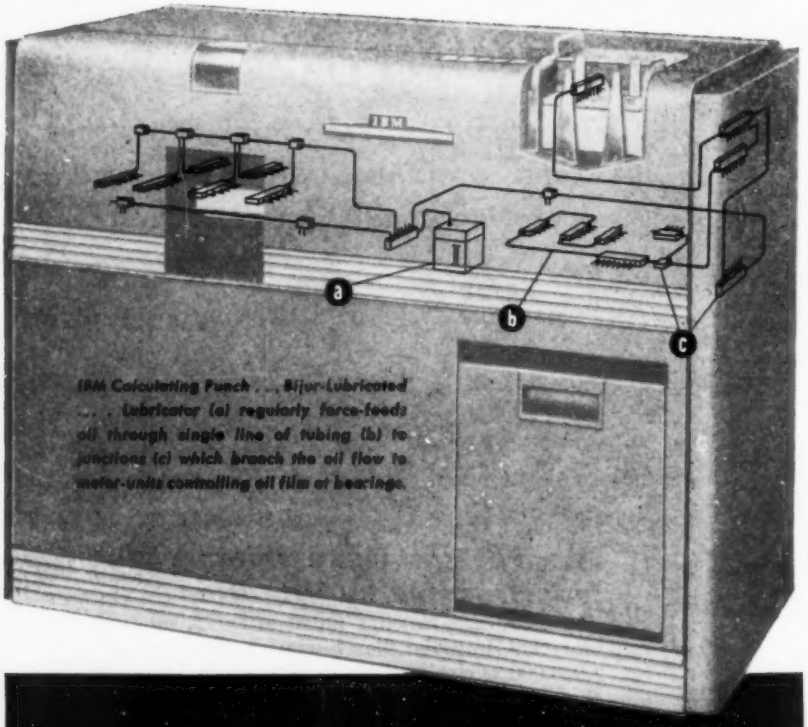

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All 109 bearings of this machine must be oiled at once *during operation* to maintain continuous production. The Bijur system does the job by connecting all bearings to one lubricator, driven by the machine.

No sign of a system is seen outside the machine as it is completely built in at time of manufacture. This makes for a compact internal design and a clean-lined exterior.

All bearings are oiled at once, yet each one receives individual attention from Bijur, the system with positive Meter-Unit control of oil flow *at the bearings.*

For further details write for "The ABC of Modern Lubrication."

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powder metallurgy, thermochemical coated metal powders, metal powder parts as friction material and other topics of interest to the executive as well as the engineer.

The Proceedings contain all the formal papers with discussions and the transcript of an interesting informal discussion on powder metallurgy. They cover the two-day meeting sponsored by the Metal Powder Association for the metal powder industry and held in Detroit in April, 1950. Titles of papers and authors are: "Thermochemical Coated Metal Powders", J. E. Drapeau, Jr., Metals Refining Co.; "Cost Accounting with Reference to Powder Metallurgy Products", A. J. Langhammer, Amplex Manufacturing Co.; "Application of Iron Powder in Radio and Television Circuits", F. W. Edwards, Standard Coil Products Co., Inc.; "A New Type of Stainless Powder", G. Stern, American Electro Metal Corp.; "The Use of Metal Powder Parts as Friction Material", L. P. Kane, S. K. Wellman Co. and "Metal Powders in a Competitive Market", John Sasso, Business Week Magazine.

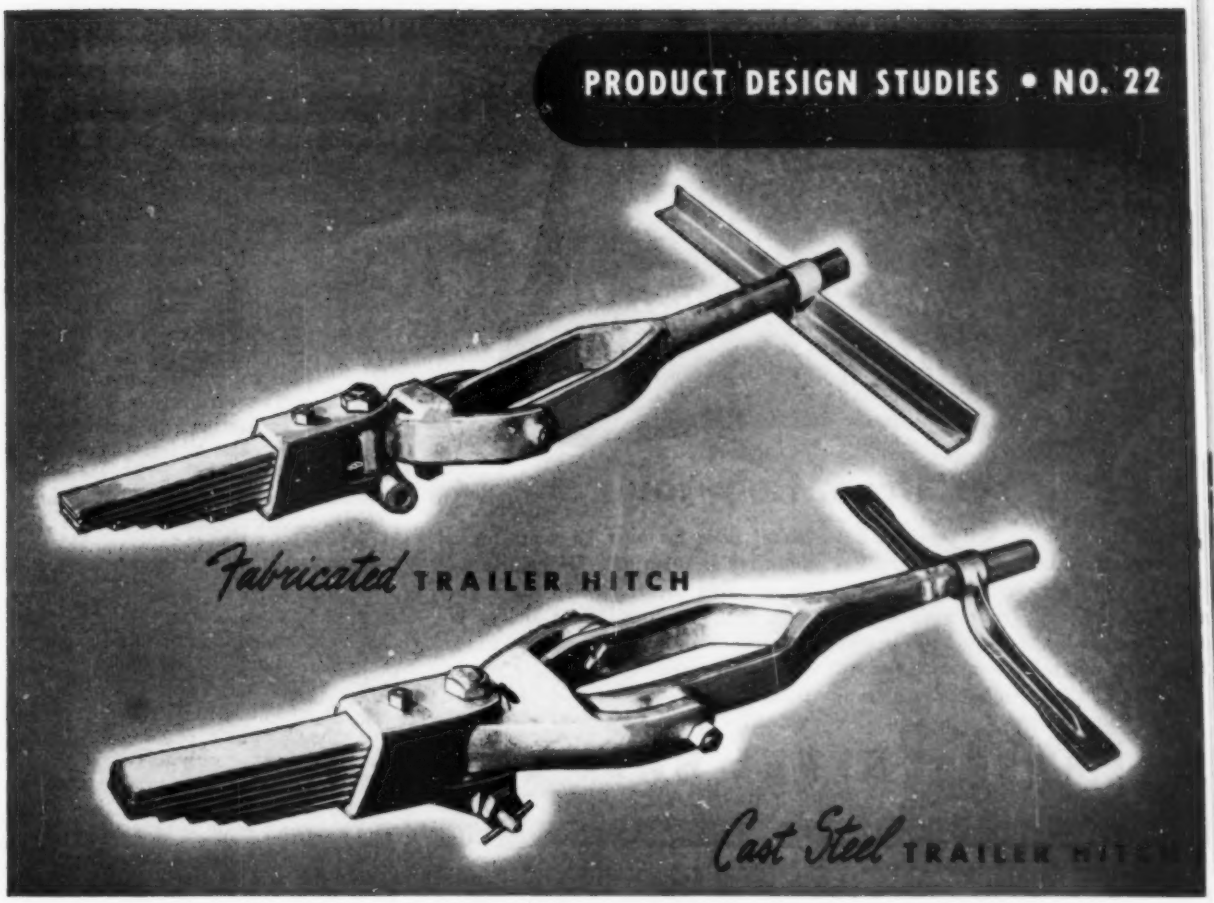
Recommended Practices For Resistance Welding

Prepared by AWS Resistance Welding Committee. 58 *pages,* 9 x 6 *in. Published by American Welding Society,* 33 *W.* 39*th St., New York* 18, *N. Y.* $1.

The data contained have been compiled by the AWS Resistance Welding Committee, through its respective subcommittees, by canvassing users of the resistance welding processes and correlating the data thus obtained. The resulting welding schedules shown in the tables were circulated for comments and, in addition, tests were conducted to ascertain that welds of the specified strengths could be obtained.

The 41-man committee, drawn from companies and government agencies representing every phase of manufacturing, fabrication and application of resistance welding has put forth recommended practices for spot and seam welding, for projection welding and flash welding. Standard testing procedures are also covered. Dimensions, spacing, current, design strengths, electrodes, and materials are included in each set of recommendations.

It is important to recognize that these recommendations are not presented as the only possible conditions for welding the materials and thicknesses shown; they are rather offered as a guide for setting up welding sched-



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Because of the great improvement in appearance, cut in costs, and increase in durability gained through the use of a *foundry engineered* steel casting for *one* part, the manufacturer of this car trailer attachment turned to the steel foundry for assistance in redesigning the entire assembly.

The photographs above tell only part of the story of the advantages obtained by conversion of all four fabricated parts. For example, tests of the rear yoke *steel casting* (crotched part at right of center) showed no deformation up to 8,000 lbs. load. *Fabrication* of same part tested in an identical manner started to bend at 1,500 lbs. and was not usable for further tests because of permanent deformation.

Bonus benefits resulting from the use of steel castings were a 20% reduction in costs and 5% cut in weight. (A 75% savings in machining of steel castings more than offset their slightly higher unfinished costs.)

* * *

Here is another example of the engineering teamwork in design and redesign of parts which is resulting in lower costs and greater serviceability with steel castings.

Two Important Announcements . . .

***Award Program*—15 substantial cash awards for papers on new and redesigned steel castings and conversions. Write for full information.**

***Steel Castings Handbook*—1950 edition; completely revised. 520 pages; 440 illustrations; 120 tables; durable binding. Price $4.00 per copy.**

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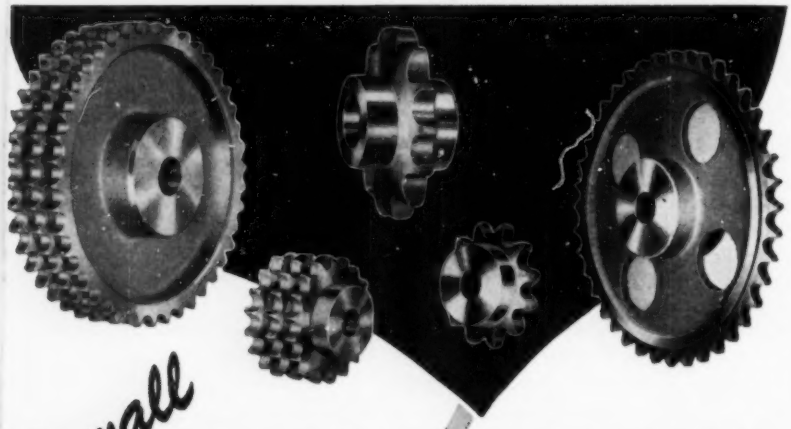

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ules to be followed in any particular fabrication, modified according to the specific fabricating conditions and production requirements involved.

The present edition represents an extension of the data originally presented in the 1946 edition to include information for some new materials and additional thicknesses. All of the tables have been rearranged to make them more readily useful for both shop and engineering department. Information of interest to the shop has been grouped at the left side of the tables; information needed by the designer has been grouped at the right side of the tables. The Committee is continuing its activities to provide data for additional materials. These recommendations will be revised as such new information becomes available.

The text has been kept as brief as possible and all extraneous comment has been omitted. For more detailed information on the equipment used, the techniques for different materials and joint design for resistance welding, the Welding Handbook, Third Edition can be consulted.

The committee has prepared these Recommended Practices in the hope that they will serve as an incentive for industry to develop methods and procedures improving upon the practices presented, which will permit the raising of quality and performance standards.

Engineering Economy

H. G. THUESEN, *Registered Professional Engineer, Oklahoma Agricultural and Mechanical College.* 501 *pages,* 6 x 8½ *in. Published by Prentice-Hall, Inc.,* 70 *Fifth Ave., New York, N. Y.* $6.65.

Engineering is essentially a means of obtaining desired results with economy. The engineer's approach to the solution of problems has been so successful that his field of activity has broadened to the extent that his success now depends as much upon his ability to cope with economic aspects as with physical aspects of situations.

Throughout this book the fact is stressed that the purpose of engineering economy is to arrive at decisions of what action to take in the present that will prove fruitful in the future. The subject is presented as an aid to judgment, analyses being directed to evaluating the future economic effect of factors individually and in combination.

Young engineers tend to disregard economic factors and are often ap-

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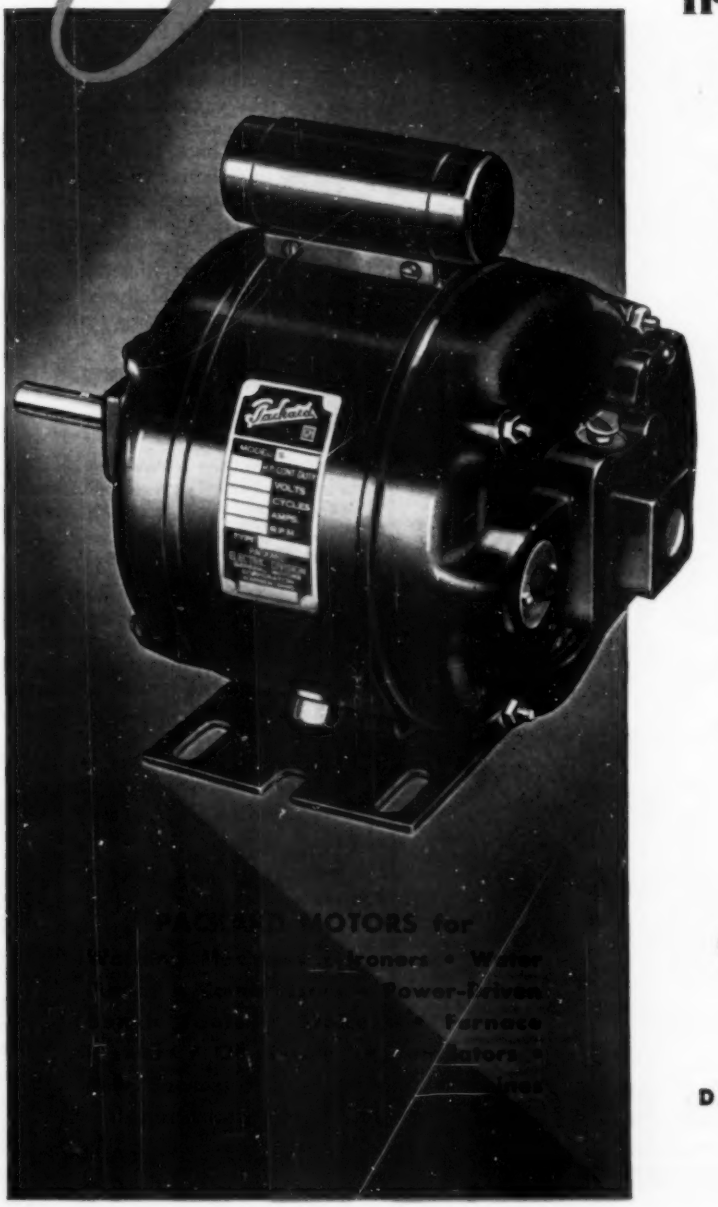

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STAINLESS STEEL FASTENERS

palled at the necessity for making decisions in situations where reliance must in large measure be placed upon estimates and judgments. To be most successful, they must learn to make sound use of both.

Much emphasis is given in this book to the fact that the forerunner of engineering application is economic feasibility. The engineer who aspires to a creative rather than a responsive role will find proficiency in economic analyses a necessity. A similar proficiency is of paramount importance to the increasingly large number of engineers who eventually become engaged in the activities of management. This trend in employment is recognized by a quantitative economic approach to some aspects of management in Chapter 17, Economy and Utilization of Personnel.

The fact that the engineer must satisfy human wants as they are rather than as the engineer may wish them to be is discussed at some length. In general, this book aims at the extension of quantitative thinking to situations embracing engineering and economic factors. Numerous approaches and methods of analyses are presented, most of which are illustrated by concrete examples. Methods and concepts are in many cases further illustrated in graphic form.

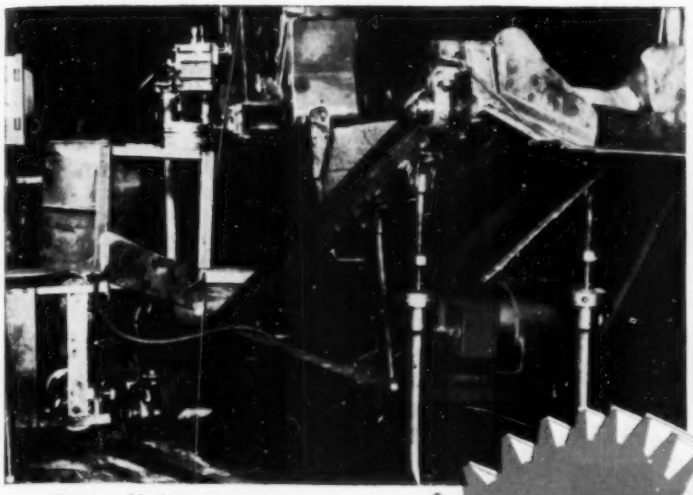
Primary Batteries

GEORGE WOOD VINAL, *Sc. D., Physicist, National Bureau of Standards. 336 pages, 6 x 9 in. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. $5.*

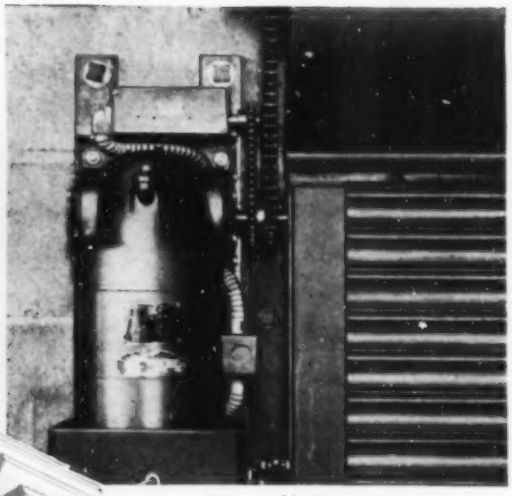
Not since 1915 has one book so thoroughly covered primary batteries. This specialized treatment offers a wide range of information—history, theory, materials, chemical reactions, manufacture and operating characteristics.

Much recent data are included which have been derived from the use of new research tools such as the electron microscope, x-ray spectrograph, mass spectrograph and the petrographic microscope. "These have been applied," says Mr. Vinal, "to study the crystal structures of the solid phases resulting from discharge and the gases liberated during periods of storage."

Covered for the first time in their modern forms in any book are several new types of special-purpose batteries. Included are batteries for operation at low temperatures, for giving large currents, for producing more energy per unit of weight and those which remain inactive until required for use. Practical, detailed material is presented



Century ¼ horsepower gear motor driving a conveyor



Century ½ horsepower gear motor operating a door opener

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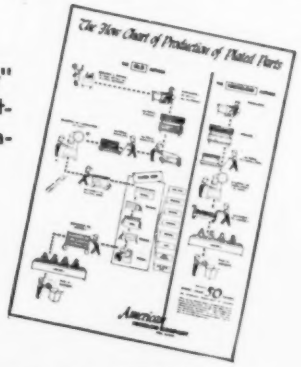

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on silver oxide and chloride batteries, mercury oxide batteries and perchloric and fluoboric acid batteries.

Of particular value to those dealing with precise electrical measurements is the thorough chapter on standard cells (standard of emf). Among other aspects it gives history, a general discussion, preparation, assembly, intercomparing electromotive forces and temperature control.

Since 1918, George Wood Vinal has been Chief of the National Bureau of Standards' Division of Electrochemistry. For over 25 years he has had active charge of the primary standard of the volt in the United States.

Strength of Wrought Steels At Elevated Temperatures

R. F. MILLER *and* J. J. HEGER. *Special Technical Publication No.* 100. 112 *pages*, 8½ x 11 *in. Published by the American Society for Testing Materials*, 1916 *Race St., Philadelphia* 3, *Pa.* $3.

This book is a compilation of a wide variety of published information, and presents important data in a graphical form. These graphs are based on tests conducted on standard, commercial grades of steel. Tensile strength, creep rates and rupture properties are given.

Divided into two sections, the book has 52 pages covering the plain carbon and alloy steels containing molybdenum and up to 3 percent chromium. The second part covers ferritic and austenitic steels with more than 5 percent chromium, including many of the stainless steels.

The introduction contains graphs that comparatively illustrate the important properties of each of the metals covered presented in detail. These charts are for maximum temperatures of from 1,200 to 1,500 F. For each steel given, not only is the composition given, but the applicable ASTM specifications are listed. A bibliography is also given from which these data were obtained.

Metals and Alloys

Compiled by the Technical Staff of Metal Industry. 214 *pages*, 5½ x 8½ *in. Published by Chemical Publishing Co., Inc., 26 Court St., Brooklyn* 2, *N. Y.* $5.

This book lists alphabetically and gives the composition of 4,600 nonferrous alloys. In tabulating these metals, the commercial name is used; if there is none, the alloy is listed

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"Caterpillar" DW20 Tractor and W20 Wagon at work on a heavy earth-moving job.

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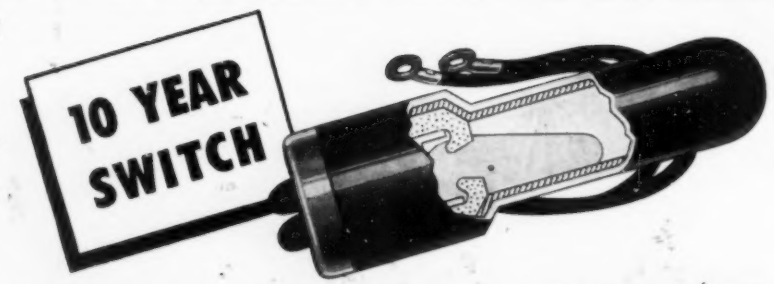

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under its appropriate heading, such as: Brasses, Bronzes or Copper-Nickel alloys, and then under the function which it serves. Alloys covered in this list are those usually regarded as non-ferrous which do not contain more than 50 percent iron. Also included are numerous European alloys. This book will be useful to those who require a reference which simply gives the composition of non-ferrous alloys.

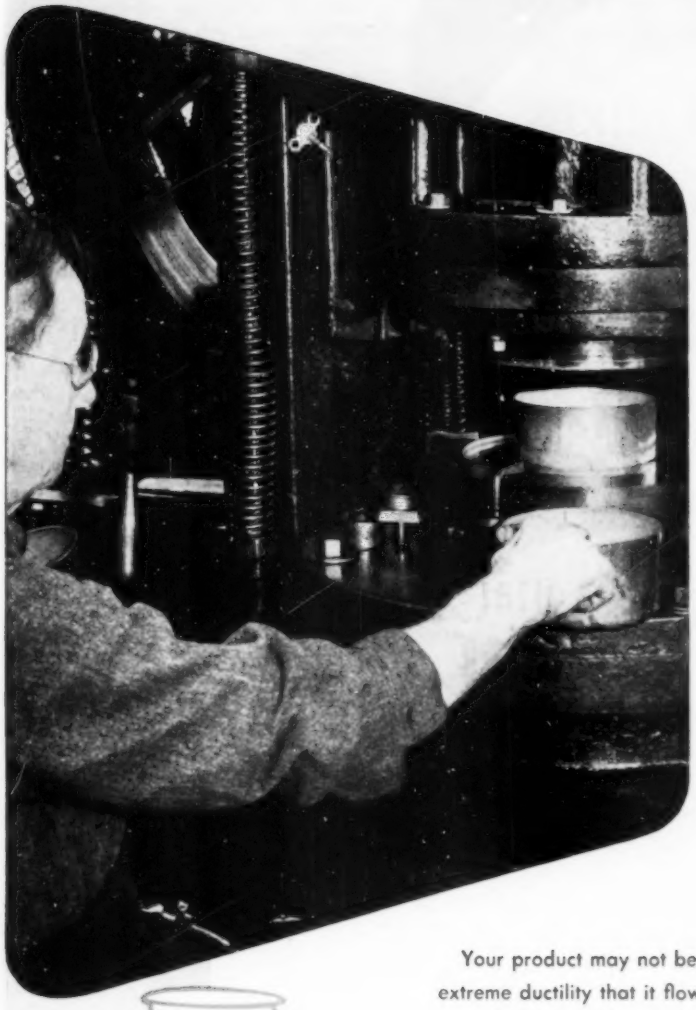
Data on Corrosion- and Heat-Resistant Steels and Alloys—Wrought and Cast

Sponsored by ASTM Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys. Special Technical Publication No. 52-A. 79 pages, 6 x 9 in. Published by American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. $2.50.

The data in this publication represent (a) an interim revision of the "Tables of Chemical Compositions, Physical and Mechanical Properties of Wrought Corrosion-Resisting and Heat-Resisting Chromium and Chromium-Nickel Steels", published by the ASTM in 1942, plus (b) an entirely new section of data on cast iron-chromium and iron-chromium-nickel alloys, not previously included in this publication. This is the first edition of these tables in which data for the cast alloys are presented along with that for the wrought materials.

The present classification provides data on those stainless steels that have received the widest commercial usage. The data have been divided into two parts—Part I on Wrought Alloys, and Part II on Cast Alloys. Section A of Part I covers the wrought hardenable and nonhardenable ferritic straight chromium steels. The ferritic steels hardenable by heat treatment are indicated in the tables as martensitic and those not hardenable as simply ferritic. Section B of Part I covers the wrought austenitic chromium-nickel steels. Part II covers the cast alloy materials of these general compositional ranges. Section A of Part II covers the corrosion-resistant alloys and Section B the heat-resistant alloys.

The revision of the wrought steel data has been limited to bringing them up to date and to the inclusion of certain data on recently developed steels not presented in the previous edition. The data on these new steels are not as complete as those on the old (for example, accepted creep strength curves are not available for the new steels), but it was thought best to publish now such data as were available of the desired caliber rather



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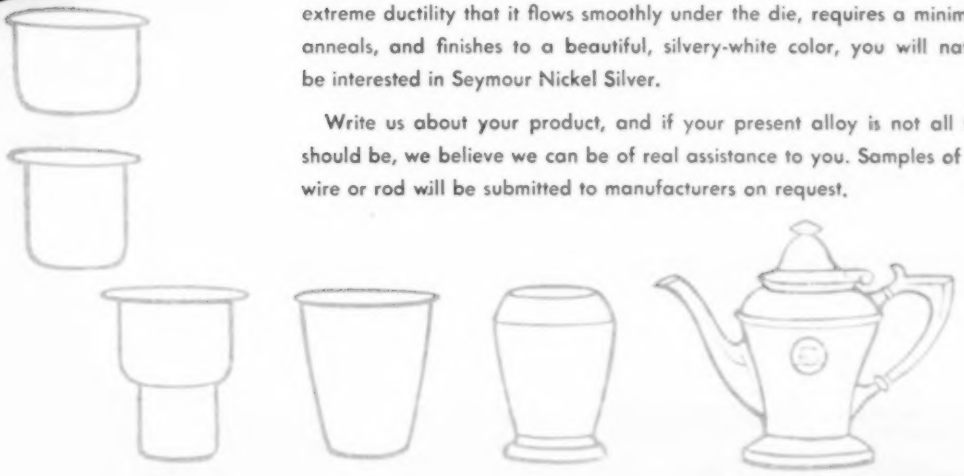

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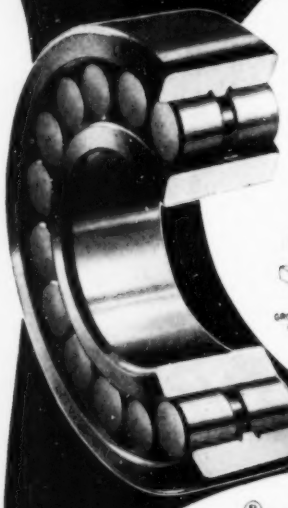

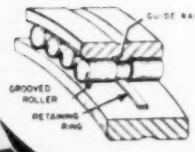

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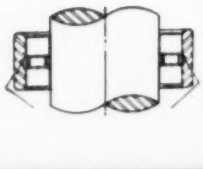

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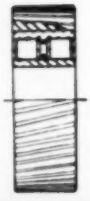

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than to delay the publication many months until complete data could be obtained. It is expected that complete data for these steels will be included in the next revision of the tables.

The data for the different steels have been condensed to the simplest form to provide a ready reference for both the maker and user of the steels. Inspection has been made of a large amount of data, and those included herein provide the present representative information on the steels covered, as obtained from both producers and consumers. Single figures rather than ranges have been used to describe the several properties of these steels. These figures are representative values and not minimum or average values except where otherwise noted in the tables. The values in these tables should not be considered as specification figures as these may be found in the appropriate ASTM standards for this class of material as referred to in the tables.

Data on the high-chromium and chromium-nickel valve and die steels have not been included since these steels are not used for general constructional purposes requiring heat and corrosion resistance. Data are not given for the chromium-silicon valve steels nor the predominantly austenitic chromium-nickel valve steels that contain 12 to 14 percent chromium, 12 to 14 percent nickel, several percent tungsten and approximately 0.40 percent carbon. Data are not given for the die steels that contain 12 to 14 percent chromium and from 1.50 to 2.50 percent carbon with small percentages of other elements, such as cobalt, molybdenum, tungsten, and vanadium.

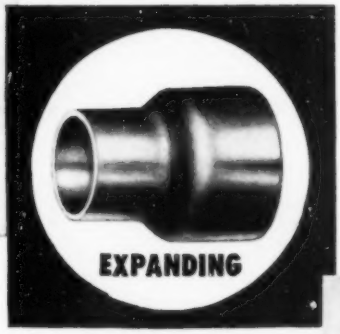
Whereas most of the cast data shown have been selected from an array of information, there are some cases where only one source was available. Rather than leave a blank, such discrete data have been included in the tables with an indication of their character.

Because of the nature of certain alloys, ranges have been used to express some of the high-temperature properties since these values may vary within the normal spread of chemical composition.

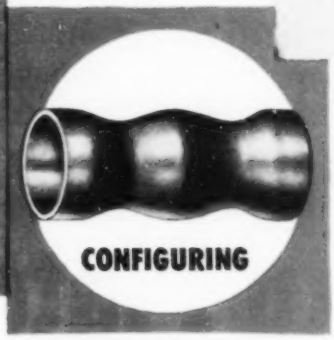
Welding Patent Classification

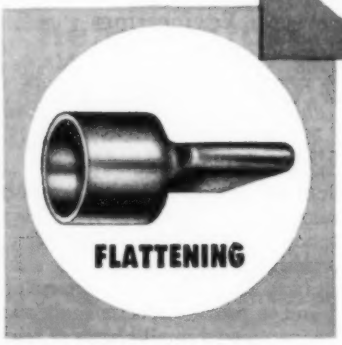
ROBERT S. GREEN, *Chairman of Welding Engineering Dept. Published by College of Engineering, Ohio State University, Columbus, Ohio.* 75 cents.

The tremendous amount of data in the literature on patents has seriously handicapped the organization of in-



Severe Fabrication?





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dexing systems and cataloging systems. The classifications set up by the U. S. Patent Office are often of little help. It has been felt that special indexing files of patents in certain fields of engineering should be set up.

The A. F. Davis Welding Library has kept a collection of patents relating to the welding industry. The classification system described in this book is an attempt to make this collection easier to use for industry and research.

A numerical file of patents is kept on the shelves. The classification cards of the patents are filed in two classes, General Divisions and Industrial Applications. These are divided under eight and eleven subheads, respectively. Cards in subheads are divided again into as many as 100 classes. A punched card system permits rapid sorting.

This card system permits an investigator to sort out rapidly all patents relating to any special phase of welding. A book list enumerates all classifications and subheads for reference purposes.

Questions and Answers In Television Engineering

CARTER V. RABINOFF *and* MAGDALENA E. WOLBRECHT, 300 *pages*, 6 x 9 *in. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York* 18, N. Y. $4.50.

Here are practical, detailed answers to hundreds of questions concerning all phases of television engineering. It is designed to coordinate the technical facts in this rapidly expanding field and to provide concise study and reference material in all phases of television. All the subjects have been selected because of their direct applicability to television from the standpoint of either the transmitter or receiver.

Typical mathematical problems are included, together with Government laws, standards, and regulations. Many of the types of questions presented are similar to those in the first class radiotelephone license examinations given by the Federal Communications Commission. A careful effort has been made to follow a logical order in grouping the subjects of each section of the book with reference to these examinations. Of special interest is the concluding section which analyzes the functions of the components in two standard television receivers that have many outstanding differences in design and circuit principles, thus reflecting the technical developments of modern television sets. Most of the

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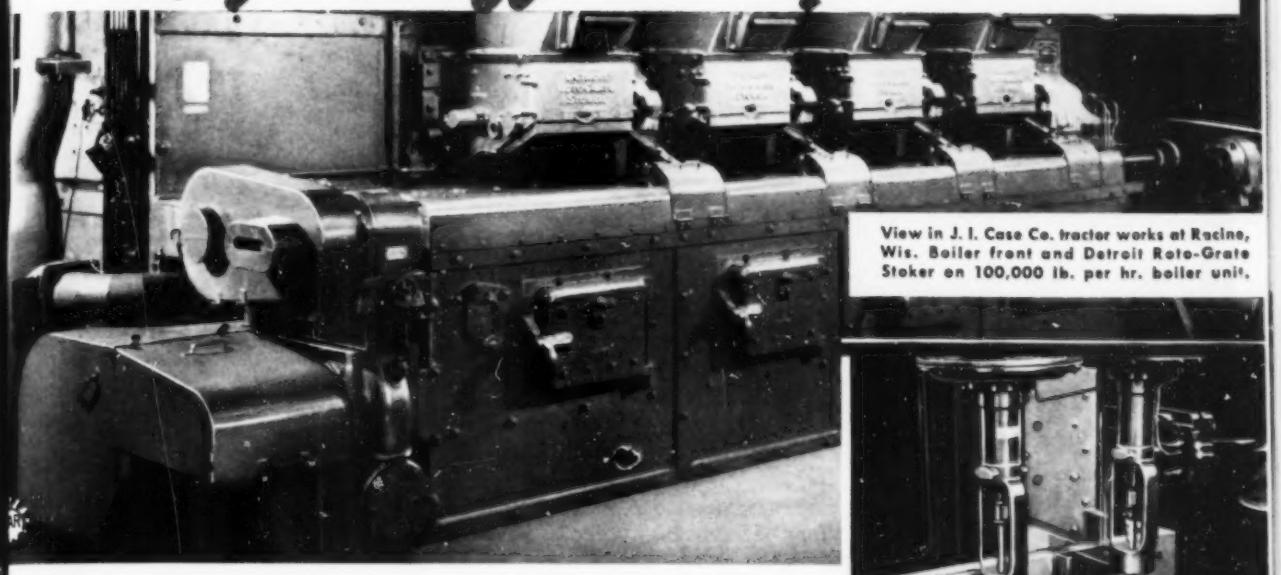
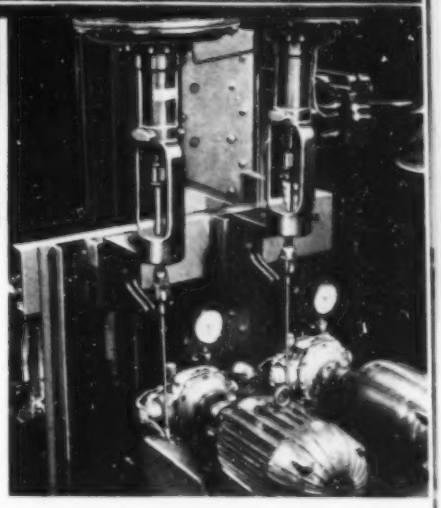


View in J. I. Case Co. tractor works at Racine, Wis. Boiler front and Detroit Roto-Grate Stoker on 100,000 lb. per hr. boiler unit.



Two Oilgear Variable Delivery Pumps with simple diaphragm actuated hydraulic servomotor lever controls supply fluid power for the fuel feed and grate drives. An Oilgear drive was experimentally installed on the fuel feed on the first stoker in 1948. On the basis of its performance, Oilgear drives were used for *both* fuel feed and traveling grate on a second stoker unit installed in 1949. Also, Oilgear will replace the mechanical grate drive on the first stoker installed in 1943. Like a shadow, flexible, controllable Oilgear *Fluid* Power causes fuel feed rate and grate speed to accompany steam demand up and down. Recording charts show steam *demand* varies "all over the place," but steam pressure and fuel air ratio stay steady.

And Oilgear's Range and Control help capture savings hidden in J. I. Case 100,000 lb. Boiler Unit

The 100,000 lb. per hour boiler unit in the J. I. Case Co. tractor works at Racine, Wisconsin, has demonstrated that it is one of the highest efficiency units in the United States. To obtain such high efficiency, careful tests of variable speed drives for fuel feed and grate travel were made during two years. Finally, Case engineers selected Oilgear Fluid Power Drives, for, as Mr. Cole H. Morrow, Chief Plant Engineer says, the Oilgear units proved far superior to electric drives and mechanical transmissions under actual operating conditions.

SMOOTH, POSITIVE SPEED VARIATION "In order to obtain high efficiency in any boiler unit," says Mr. Morrow, "*a very precise variable speed fuel feed drive* is required to meet widely varying demand. The Oilgear Drive gives smooth, positive variable speed operation from zero to 100% of capacity with a straight line fuel feed characteristic. This allows us to calibrate the control system for operation within amazingly close limits of fuel-air ratio variation.

EASE OF CONTROL "Also, on this type of stoker the grate speed must be infinitely variable from minimum to maximum yet maintained in direct proportion to the rate of fuel feed. Every change in fuel feed requires an immediate and directly proportionate change in grate speed. (Such synchronization) is easily obtained with the Oilgear drive units because of their ease of control, and the simplicity and low force requirements of the control mechanism."

UNLIMITED SPEED RANGE Also, fuel feed and grate drives must have a range of speed at least equal to the demand range. Most drives have a range not exceeding 4 to one. Yet at Racine, during the summer, demand drops far below the 25,000 lb. threshold imposed by such a ratio. The Oilgear Drives however have no "ratio" limits, would function down to zero load if necessary. In fact, they give precise load control down to a load of 15,000 pounds per hour normally obtained each day during the summer, and down to as low as 5,000 pph over the weekends still under full automatic control.

OUTSTANDING RELIABILITY "One of the outstanding features we discovered . . . was the *reliability of the Oilgear units*. The experimental installation operated almost continuously for a year and a half without any difficulty. This record was far better than we were able to obtain with any other type of drive or transmission."

These four features, variability, ease of synchronization and control, actual range from zero fpm, rpm or torque up to maximum, and reliability proven over and over again, are indications of the many advantages Oilgear drives and transmissions offer in machine design and use. Investigate Oilgear equipment as a *better* solution for your problems. THE OILGEAR COMPANY, 1571 West Pierce Street, Milwaukee 4, Wisconsin.

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answers are given in essay form and are written to be informative as well as explanatory.

An Appendix gives the proposed FCC changes in standards and rules for commercial television in the ultra-high-frequency channels. They are summarized in the Appendix under the following headings: Additional television channels; Frequency assignments in the UHF band; Metropolitan and community stations defined; Field intensities for various grades of service; Permissible interference ratios; Separation of stations in miles; Authorized effective radiated peak power; Auxiliary stations defined; Television pickup station; and Frequency assignments for television auxiliary stations.

Handbook on Designing For Quantity Production

HERBERT CHASE. *Second Edition*, 564 pages, 6 x 9 *in. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York 18, N. Y.* $7.50.

Herb Chase is a well-known figure in the technical writing field. He has been covering the industrial scene now for many more years than he cares to remember, and the Handbook on Quantity Production is a condensation of the wealth of information he has accumulated over the years on various production methods. This second edition has been revamped and re-edited to bring it up to date in terms of modern industrial requirements, to make it easier to use, and to make it more practical.

Part I includes specific chapters devoted to the more important types of metal products. It covers the design of die-forged parts, die castings, permanent-mold castings, screw-machine products, stampings, plastic moldings, and many other metal products. There are chapters on wire forms, permanent-mold castings, impact extrusions, and sintered powder compacts.

Part II discusses in detail the advantages and limitations of each of these methods of production, gives specific data on the specification of a product manufactured by one of the methods, and includes a wealth of design data.

While Mr. Chase is both editor and author of many of the 21 chapters in the book, he also has called upon specialists in industry and the educational field to prepare several chapters. For example, Design of Sand Castings is authored by Norman F. Hindle, Assistant Professor of Mechanical Engineering, University of Idaho. The Design of Screw-machine

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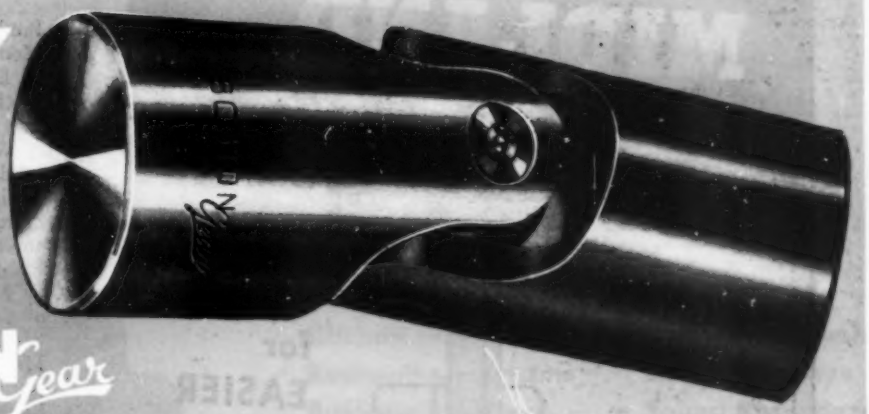

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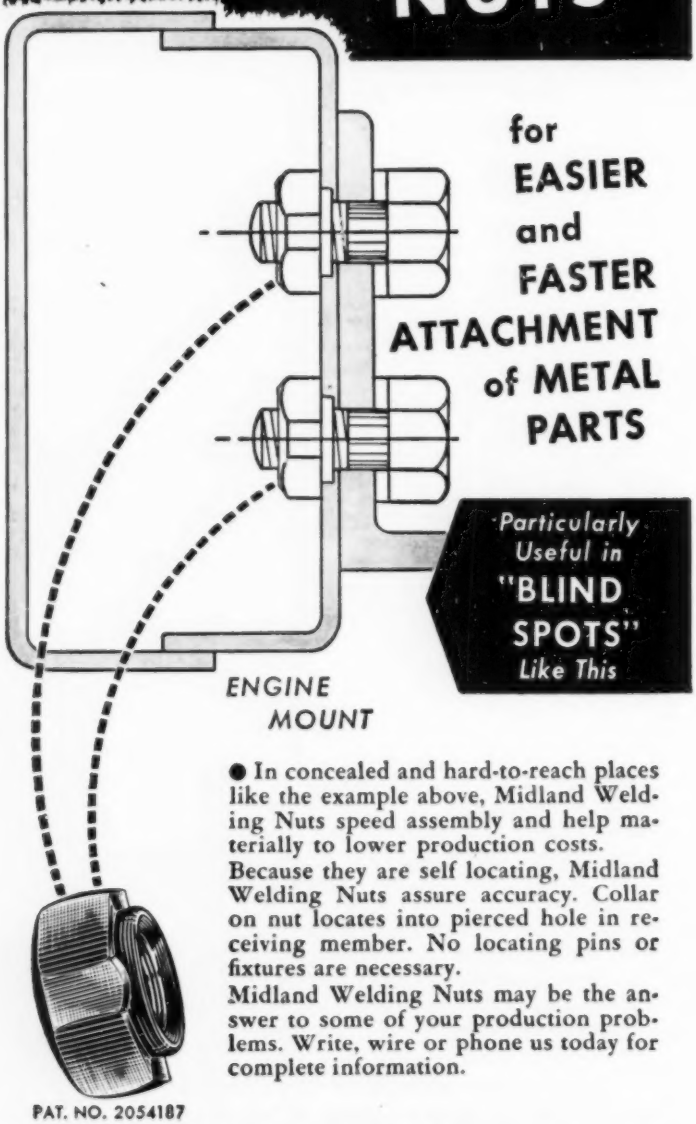

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Products is co-authored with Mr. D. H Montgomery, Vice President in Charge of Engineering, New Britain Gridley Machine Company. Design of Stampings is the result of work by Mr. Ralph A. Wagner, Chief Tool Engineer, Consolidated Vultee Aircraft Corporation. Design of Die Forged Parts is authored by Charles L. Tutt, Jr., Assistant to the President, General Motors Institute. Hot Heading was prepared by Mr. Chase and A. E. R. Peterka, of the Lamson & Sessions Company, and Design of Plastic Moldings by Mr. Furholmen, formerly Chief Estimating Engineer, Chicago Molded Products Corporation.

For the designer who is not well acquainted with all of the various production processes, the book is a must. However, since a series of books could be written on the subject matter covered by any one of the chapters, it necessarily is general in nature in many respects, and cannot be used as a reference book by a designer of specific parts.

Inelastic Behavior of Engineering Materials And Structures

ALFRED M. FREUDENTHAL, *Professor of Civil Engineering, Columbia University.* 587 *pages,* $5\frac{1}{2}$ *x* $8\frac{1}{2}$ *in. Published by John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y.* $7.50.

With the continual struggle toward more efficient machines, great strides have been made in the aerodynamical analysis of modern airplanes, as well as in the thermodynamic analysis of gas turbines. By comparison, the concepts and methods used to proportion machine parts appear crude. Consequently, there is a need for a more effective approach to the study of the behavior of materials.

Since most of our knowledge concerning the mechanical behavior of engineering materials is derived from large-scale observations, empirical interpretations are often necessary, due to partially coordinated data. As materials increase in complexity and the number of operating conditions of the applications become more diversified "laws" must be devised. Such "laws", in general, are valid only within the range of observation that were used in the derivation.

The author has endeavored to present the development of a more fundamental approach to the mechanical behavior of engineering materials. This can be done only with a knowledge of the basic concepts governing

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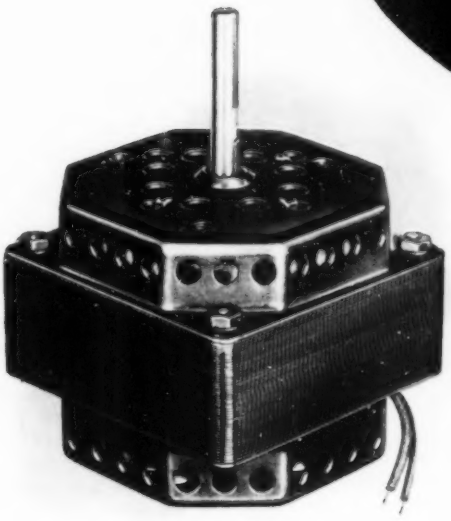

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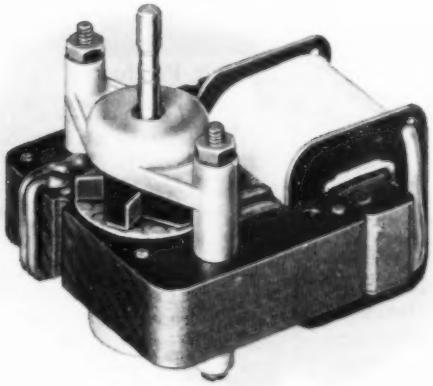

✓ **MODEL A . . 1/125 to 1/200 H.P.**

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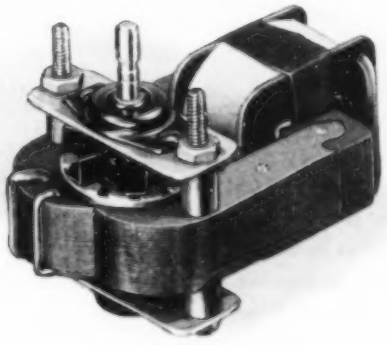

✓ **MODEL C . . 1/250 to 1/500 H.P.**

2-pole, shaded pole induction motor. Features include accurately aligned motor shaft . . . oilless bearings.

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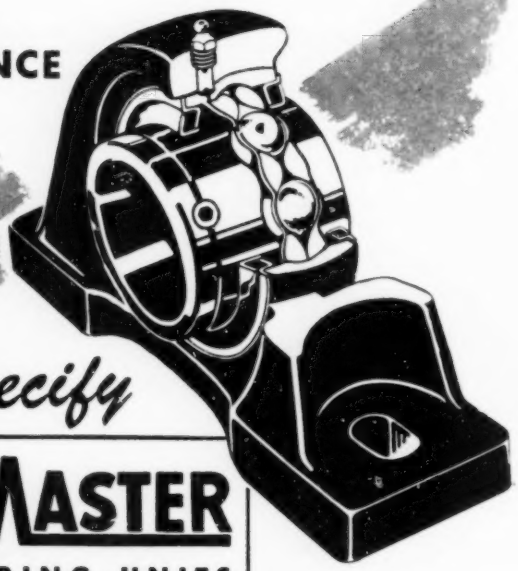

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Bearing unit, with seals independent of housing, aligns itself without seal distortion.

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the formation of matter from particles and larger structural elements at different levels of aggregation. Thus the deformational properties of single crystals are closely related to the principles governing the formation of the crystal from atoms, ions or molecules. Likewise, the physical properties of polycrystalline metal aggregates are essentially determined by the laws of formation of such materials from single crystals or giant molecules.

This book has been prepared as a graduate textbook on the theory of inelasticity which is the theory of the general deformational behavior of engineering materials under the action of force, time and temperature. There are three sections: Part A discusses the structure of matter and structural theories of deformation; Part B delves into the mechanics of inelastic deformation which includes plasticity, work hardening, creep and fracture; Part C presents selected problems in the mechanics of inelastic behavior.

The last part should be of particular interest to designers, since important information is given concerning the design of machine parts under conditions of plasticity and creep. The significance of mechanical testing and the proper interpretation of the results are discussed in this section. For further study, there is a bibliography at the end of each chapter.

A.S.T.M. Standards on Rubber Products

Prepared by Committee D-11 on Rubber Products. 9 x 6 *in.*, 625 pages. *Published by American Society of Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.* $4.75.

All the standard and tentative test methods and specifications pertaining to rubber products are included. Among others, the materials and subjects covered include processibility tests of vulcanized rubber, aging and weathering tests, low-temperature tests, automotive and aeronautical rubber, hose and belting, tape, electrical protective equipment, rubber-coated fabrics, insulated wire and cable, hard rubber, latex foam and sponge, rubber cements, rubber latices, packing materials, nonrigid plastics, electrical tests and nomenclature and definitions. Tests are identified by a permanent ASTM designation.

Typical tests standards include general methods, sampling procedure, specimen dimensions, test conditions, number of tests, apparatus, procedures and purposes.

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S-10	1/10 sec.	1000 sec.	± .02 sec.
S-6	1/1000 min.	10 min.	± .0002 min.
S-1	1/100 sec.	60 sec.	± .01 sec.
MST	1/1000 sec.	.360 sec.	± .001 sec.
MST-500	1/1000 sec.	30 sec.	± .002 sec.

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are proposed methods, which are published in draft form for the purpose of soliciting comments. Such proposed methods have not been fully approved by the Society and are distinguished from the standards and tentatives by the absence of an ASTM serial designation. The regulations governing Committee D-11 and a complete list of its personnel are also given.

Papers on Industrial Hydraulics

Proceedings of National Conference on Industrial Hydraulics, Vol. III, 1949. 218 *pages,* 6 x 9 *in. Published by Armour Research Foundation of Illinois Institute of Technology, Technology Center, Chicago* 16, *Ill.* $3.

The National Conference on Industrial Hydraulics has collected in this volume 19 papers submitted at the 1949 meeting. A genuine effort has been made to produce illustrations and text that are readible and interesting. These are no long-winded polemics, put out for the interest of a few people wrapped up in mathematical hydraulics. The meat of each paper is laid out for quick appreciation by any design engineer, in or out of the hydraulics, field.

The first papers presented deal with recent developments in applied hydraulics. The first article covers the increase in hydraulic power application in tractor design and the systems now used. A power transmission system is next discussed in detail. An outline of large valves now in use, with their characteristics and applications, concludes the section.

A second group of papers deals with hydraulic components, pumps and turbines, technical design data and equipment standards. One article touches on commercial seal types, and the effect of operating conditions and seal material on design choice. The best applications of radial and axial fabricated seals are explained. Differences between synthetic and petroleum base operating fluids are discussed by another contributor. A summary of fluid and hose fire-resistance tests is presented with a complementary paper on the fire resistance of synthetic fluids.

One of the most interesting topics is covered in this section. A clearly written, mathematically logical outline of electrical and hydraulic servo-motors concludes with an overall comparison of the two power sources. This is heavy reading, but rewarding.

The section is rounded out with technical treatment of pressure tran-

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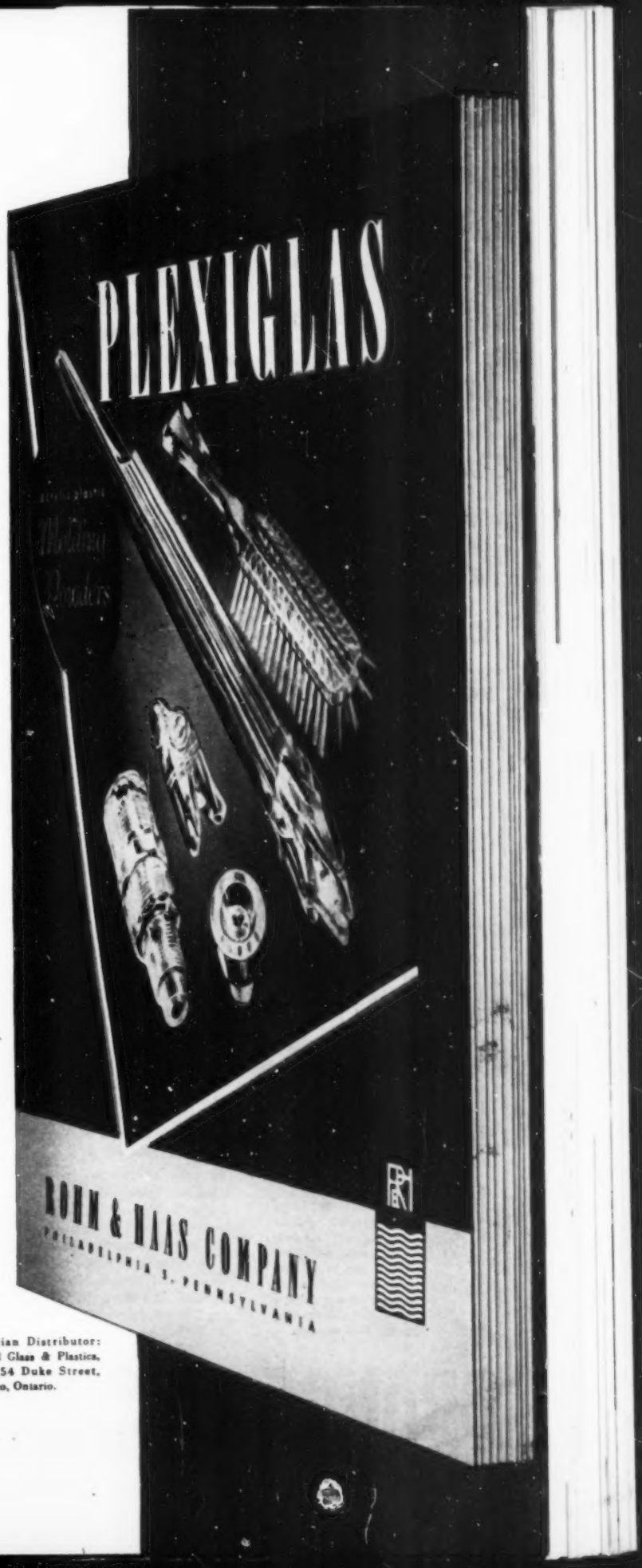

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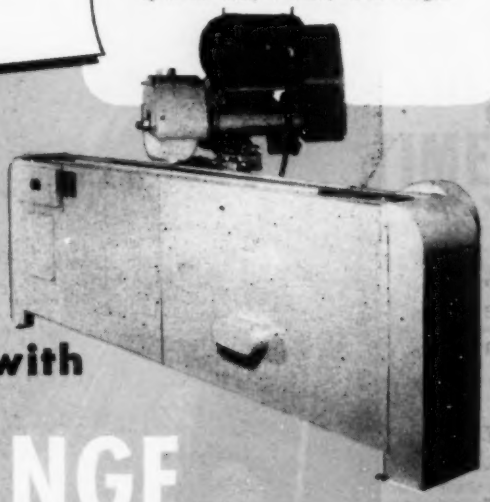

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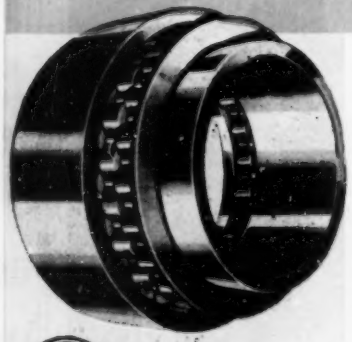

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sient measurements and two papers on the benefits and effects of the Joint Industry Conference Standards. The standardization program is seen from both sides and there is some interesting reading here.

The last group of papers is on hydraulic applications. An outline of hydraulic power and its possible aircraft propulsion uses is somewhat out of the field but earns its place by giving a one-syllable coverage of the industrial outgrowths of the A-bomb. Hydraulic practice in mixing and machine tools is included in the same group. A water supply system and the hydraulic layout of a Lockheed airplane are interesting examples of applied technology.

This volume represents a type of presentation that should be used more often. The engineering profession as a whole gets a look at the recent trends in a specialized field and a resume of interesting aspects of current practice in that field.

Pocket Encyclopedia of Atomic Energy

FRANK GAYNOR. 6 x 9 *in.*, 204 *pages. Published by Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y.* $7.50.

The purpose of this book is to present a comprehensive collection of brief explanations and definitions of concepts and terms in the field of Nuclear Physics and Atomic Energy to the scholar, researcher, teacher, librarian, student and intelligent layman.

There are individual entries for every element, indicating: Chemical symbol, group of the periodic table, name of discoverer, date of discovery, atomic number, atomic weight, melting point, boiling point, specific gravity, stable isotopes, radioisotopes. Brief descriptions of the best known types of nuclear reactions are given. There is an entry for every member of the known radio-active families, indicating: Symbol, atomic number, mass number, parent isotope, daughter isotope, type of radiation and half-life. There are a great many brief and concise descriptions of subjects such as nuclear fission, tracer technique, atomic bombs, the "H-bomb".

Further: Electrical, magnetic, chemical and physical units; important nuclear research laboratories, power plants and installations. Also: Thumbnail biographical sketches of outstanding nuclear physicists and chemists—in itself a pocket Who's Who of atomic science. In all, there are over two thousand entries.